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JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

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CHARLES R. HENDERSON, PRESIDENT, 1918-1919

JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

The Association is not responsible, as a body, for the facts and opinions advanced in any of the papers or discussions published in its proceedings.

VOL. 5 SEPTEMBER, 1918 No. 3

COMMENTS

DISCUSSIONS

When the Association adopted the report of the last Publication Committee it thereby approved the recommendation in that report concerning methods of making the JOURNAL more helpful and interesting to the members. One of these methods is to have the JOURNAL record the progress of important work. It is while work is in progress that it is alive; when it is finished it may be interesting and useful, but it is not interesting in the way that a job in hand appeals to us. Take the report of the Committee on the Mechanical Analysis of Sand in this number, for instance; it is a progress report, intended solely for the information of the members concerning the work of this committee and not approved in all respects by the members of the committee. But it gives an idea of one feature of the work the committee has been doing, and in this way keeps our members posted regarding a topic that was the subject of animated discussion at the Cincinnati convention.

When a piece of work has advanced beyond the stage when discussion is useful it is so far along toward completion that a good many of us will not take the time to read about it. But if we know that those investigating a subject are still discussing it critically our ever-persistent curiosity leads us to follow the discussion, if we are fortunate enough to be able to do so. The things that are discussed are the live things. The place where they should be publicly discussed is in our JOURNAL. This thought was the basis of the recommendation made by the last Publication Committee. So far as the

present Publication Committee is able to carry out the recommendation it will do so, but the members of the Association should keep in mind that these "Comments" will only be of the greatest value when they all contribute to them, or send suggestions which the Publication Committee can utilize in obtaining information of immediate value to the fraternity.

CARLETON E. DAVIS.

SHIP YARD SANITATION

So much has been said about the sanitary work done by the government at the camps and cantonments that what Mr. Greeley says in this number about sanitation at the shipyards is a timely tribute to a group of men which has been doing a fine piece of work without receiving any recognition for it. The enormous shipbuilding program of the Emergency Fleet Corporation called for the construction of new villages and new transportation facilities almost overnight. The need for ships has been most pressing. The managers of these yards thought of ship ways and shops and tracks and storage; they had no time to think of sanitation, except casually. It was to help them keep their mushroom enterprises safe in a sanitary sense, that Colonel Doane was engaged. He and his men have been out on the job most of the time. During the five months I was employment manager of the Emergency Fleet Corporation I saw him only once, at a staff dinner. He was too busy to waste any time in an office chair. But he has kept the ship yards in good sanitary condition in spite of serious difficulties, and he has done such a satisfactory piece of work that nobody was surprised when the War Department told him recently to get ready to return to the army.

J. M. GOODELL.

HOW TO OBTAIN A PRIORITY ORDER AT WASHINGTON

Municipalities and public utility companies all over the country are experiencing such difficulty in obtaining materials for operation, maintenance and new construction, that a brief statement of their obligations to the nation, as viewed by the administration at Washington, is desirable at the present time. Cities and utility companies must remember that when President Wilson told us to "give until it hurt" in order to bring the war to the earliest possible com-

pletion, his appeal was to communities and corporations as well as to individuals. The general policies which are rapidly going into effect in Washington are based on this thought, that communities must give their aid by deferring to a later day all unessential work. The difficulty is to determine what is essential and what unessential, but the War Industries Board has made enough rulings to throw light on its position in regard to the prosecution of various classes of work.

In maintenance and repair work, necessary for the upkeep of plants furnishing essential service to communities, the War Industries Board grants every assistance in its power. It cannot accomplish an impossible task, however. There are some sections of the country where important war time orders call for every barrel of cement that can be furnished by mills normally supplying that district, and the United States Railroad Administration does not favor shipments from abnormal sources of supply for a district. Every pound of steel that can be turned out of our furnaces is needed for war-time purposes, just now. Not long ago a branch of the War Department was so hampered by lack of steel that it sent out representatives to comb the jobbers' stocks and blacksmith supply houses in a large section. Pig iron is needed for many war purposes the civilian knows nothing about. In some sections north of the Potomac and Ohio and east of Indiana, the railroad congestion is so severe that important branches of the government are placing no orders there for the present. In short the government is experiencing great difficulty in securing materials to win the war, and consequently the managers of water works must not expect anything else.

While there is a general agreement that existing public utilities should be maintained in an efficient condition, there is very little probability that new construction will be possible. A suburb which has gone without water mains or sewers until now can probably go without them a year or so longer. A water plant which has been furnishing unfiltered water for some years probably cannot make an effective plea before the Washington authorities that an unsanitary condition exists which demands immediate relief. A water department in a city where the growth has been only normal will probably experience much difficulty in securing materials for new dams or pumping stations, for the federal administration is not hesitating to put the country on short rations even of essentials in

order to back most effectively our lads on the battle grounds and high seas. Everybody agrees that water of unquestionable purity and ample quantity is most desirable, but our soldiers and sailors are sometimes going without it and we can learn, as they do, to be careful of what we have.

In short, then, no water works manager should attempt to obtain materials which are not absolutely necessary to maintain his plant in its present condition, unless the new extensions are absolutely necessary for war-time industries. Every day thousands of letters praying for relief of one kind or another reach Washington, and the claim made for the relief is that the community or the district is engaged in war work very largely. Such petitions are never granted, for generalities are not accepted as evidence in Washington. Every application for relief must be accompanied by positive proof that if the application is not granted the active prosecution of the war will be checked, a heavy previous investment will be seriously impaired, the health of a large number of people who cannot be moved elsewhere will undoubtedly be placed in grave danger, or a large financial loss and great inconvenience to many persons will arise from stopping construction undertaken before the beginning of the current year.

In each case it is absolutely necessary to explain what alternative remedies have been considered and why they have been deemed inferior to that requested. The statement that larger mains must be laid to meet the needs of a growing population in any section of a city is worthless as an argument at Washington. There should be a map of the section of the city, showing the location and size of the mains serving it, records of the water pressure at different points if this is important, a statement of the number of consumers, and an explanation of what the water department is doing to prevent water waste. In short there must be just as complete a technical and administrative demonstration of the soundness of the appeal as a bank demands when it receives an application for a loan. This application should be sent to the Priorities Division, War Industries Board, Washington. Do not send a delegation or even a single representative and above all do not ask a member of Congress to help, for he cannot do anything that a proper application by mail will not accomplish better and more quickly. Applications for relief should be made out on forms which can be obtained from the Priorities Division, with instructions regarding their use.

What has been said above is merely a restatement of the resolutions passed by the War Industries Board on March 21, 1918, and published in all the leading newspapers and trade journals of the country. In order to make this important matter perfectly clear to the members, the resolutions are printed here.

WHEREAS, it has come to the notice of this Board that new industrial corporations are being organized in different sections of the United States, for the erection of industrial plants which cannot be utilized in the prosecution of the war, and

WHEREAS plans are being considered by certain states, counties, cities and towns for the construction of public buildings and other improvements which will not contribute toward winning the war, and

WHEREAS the carrying forward of these activities will involve the utilization of labor, materials and capital urgently required for war purposes; now, therefore, be it

Resolved, by the War Industries Board, That in the public interest, all new undertakings not essential to and not contributing either directly or indirectly toward winning the war, which involve the utilization of labor, material and capital required in the production, supply or distribution of direct or indirect war needs, will be discouraged notwithstanding they may be of local importance and of a character which should in normal times meet with every encouragement; and be it further

Resolved, That in fairness to those interested therein notice is hereby given that this Board will withhold from such projects priority assistance, without which new construction of the character mentioned will frequently be found impracticable, and that this notice shall be given wide publicity, that all parties interested in such undertakings may be fully apprised of the difficulties and delays to which they will be subjected and embark upon them at their peril.

The Priority Committee, and particularly its Chairman, is indebted to the editor of the JOURNAL for securing an interview with officials of the War Industries Board and preparing the above statement outlining the situation concerning priorities. The Committee endorses this statement and desires to make it its own, except in so far as the labor in obtaining it is concerned.

PRIORITY COMMITTEE,
By C. E. Davis,
Chairman.

THE PRACTICABILITY OF ADOPTING STANDARDS OF QUALITY FOR WATER SUPPLIES*

By Robert B. Morse and Abel Wolman

In spite of the fact that the attempt to establish a so-called standard to serve as a basis for interpreting or classifying the quality of potable waters has met with but little success in the past, endeavors are still being made to standardize the consideration of analytical results so as to eliminate personal judgment as a feature of interpretation. The difficulties besetting these efforts, such as the undetermined significance of the bacterial test made by various methods, the importance of varying chemical content and the evidence of sanitary surroundings, are still present in probably a greater degree than in the past, on account of the development of the science of water bio-chemistry and the added confusion created by the ever changing methods, media, temperatures, and differentiations.

Before establishing a measure of the quality of a potable water, it is necessary to determine by what units such measurements are to be evaluated. In the case of water supplies, the choice of appropriate units becomes difficult, since the question immediately arises as to whether the bacterial count, the B. coli test, the chemical determinations, or the sanitary inspection, should be the sole criterion; or if a combination of these factors, as to what their relative importance should be in any proposed unit of measure. Manifestly a standard in its simplest terms could be predicated upon any single one of the above-mentioned units, if we assume that such a standard would fulfill the requirements of a universal measure of quality. Even then the problem still remains of deciding what unit of bacterial content, for instance, shall be chosen as the basis for comparison.

* Read at the St. Louis Convention, May 15, 1918. Discussions of this paper for publication in a later number of the Journal may be sent to John M. Goodell, Cosmos Club, Washington.

A unit of measure must be founded upon the existence of an absolute uniformity of condition and of material which can be made to serve as the immutable basis for future comparative readings. The unit of length, for example, is that distance between the ends of a bar of definite material, in a definite place, measured and corrected for predetermined conditions of atmospheric pressure and temperature. Such a unit immediately establishes a precise standard by means of which further measurements of length under all conditions may be carried out. The search for a "quality standard" for water should be first directed, therefore, towards determining whether there are available any definite units in sanitary science which can serve as the basis for a standard.

If the water analysts have agreed upon well-defined methods of water analysis, then the evaluation of a standard would be at least possible, if not valuable, for interpretation. In order to learn whether any degree of uniformity existed in the laboratory examination of water supplies, a questionnaire was submitted to 33 state department of health laboratories in the United States. Thirty-two answers were received and sufficiently detailed information was obtained to warrant the conclusions later to be discussed. With these data at hand, the practicability, at the present time, of formulating a standard of quality for water, in the light of present day analytical practice, may be discussed with more precision.

Total bacterial count. The total number of bacteria in a stated quantity of water has been used frequently in establishing a maximum allowable pollution in potable waters. One of the more recent of these is the requirement of the United States Treasury Department that water supplied to common carriers should contain no more than 100 bacteria per cubic centimeter (37°—24 hours—agar). The creation of such standards presupposes a unanimity of opinion as to the significance and importance of particular bacterial counts obtained by definite procedures, over others found by any other methods. Such an agreement would be reflected, of course, in the routine procedures of laboratories. The data in table 1 disclose, however, a disconcertingly wide difference, rather than agreement, of attitude toward the various methods. If official water analysts differ in their choice of the method of making total counts, it is reasonable to conclude that their disagreement would be even greater in a choice of a "standard" total count. Since the relative significance, for instance, of the total number of bacteria on a plain

TABLE 1

Method of obtaining total bacterial count in laboratories of various state departments of health

NAME OF STATE	20°C.				37°C.				
	Gelatine		Agar		Gelatine	Agar		Lit. Lact. Agar	
	48 hrs.	96 hrs.	48 hrs.	96 hr.	48 hrs.	24 hrs.	48 hrs.	24 hrs.	48 hrs.
California						+			
Connecticut	+					+			
District of Columbia			+ (a)						
Florida							+		
Georgia						+			
Illinois	+					+			
Indiana						+			
Iowa			+					+	
Kansas	+					+			
Kentucky						+			
Maine	+					+			
Maryland			+			+			
Massachusetts				+				+	
Michigan						+			
Minnesota				+					
Missouri						+	+		
Montana						+			
New Jersey			+			+		+	
New York					+	+ (b)			
North Carolina	+							+	
Ohio			+			+			
Oklahoma						+			
Pennsylvania							+		
Rhode Island			+					+	
South Carolina						+	+		
South Dakota							+		
Vermont						+			
Virginia						+			
West Virginia							+		
Wisconsin		+ (c)							+
Wyoming	+						+		

NOTE: Data in above table obtained by letter in 1917 from officials of various state departments of health.

(a)—25°C.

(b)—Infrequent.

(c)—15° to 20°C.

agar plate at 37°C., as compared with the count on a gelatine plate at 20°C., is still a moot question, it is clear that more confusion in interpretation will result when several additional different combinations of media, temperatures, and periods of incubation are to be considered.

It is also of striking interest to note that, in spite of the fact that the 37°C. agar count at twenty-four hours incubation has been for several years an official standard procedure of at least two organizations (American Public Health Association and United States Treasury Department), only 19, or approximately 60 per cent, of the laboratories in question have seen fit to use this exact procedure as a routine measure. The percentage is undoubtedly higher than that which would represent the individual opinions of the analysts in these laboratories, in view of the fact that some of them have adopted the aforementioned methods on account of their official stamp rather than as a result of the conviction that they are superior to others. This conclusion is borne out by the fact that it has been by no means firmly established that the bacterial count, obtained as outlined by the Federal requirements, serves as the best index to the quality of a drinking water. In the light of the data illustrating the wide discrepancy in the method of obtaining the bacterial count, it would appear that effort should be directed towards further study of individual types of bacteria and their relative significance rather than towards an attempt to predicate a standard upon such an elusive and variable factor as the general bacterial count.

B. coli. An index to sewage pollution in potable waters is an excellent asset in determining the safety of a supply if it "indicates." Some years ago, perhaps, the presence of B. coli in small quantities of water was considered sufficient evidence upon which to condemn the supply. He certainly would be venturesome who would issue a manifesto today as to the allowable frequency of B. coli in a safe water. He would indeed be skillful who can gather sufficiently consistent data out of the present chaotic conception of the significance of B. coli, and of how to obtain it, to be able to establish even a fairly elastic measure of quality.

Table 2 illustrates, for instance, that the use of a medium for testing even the elementary phenomenon of gas formation is still open to question, while the significance of gas formation itself is disputed by authorities. Considerable evidence has supported previously the use of lactose bile, but the wind has apparently shifted in recent

TABLE 2

Method of making presumptive tests for B. coli in laboratories of various state departments of health

NAME OF STATE	MEDIUM USED		PERIOD OF INCUBATION	
	Lactose broth	Lactose bile	48 hours	72 hours
California	+		+	
Connecticut	+		+	
District of Columbia		+	+	
Florida	+		+	
Georgia	+		+	
Illinois	+		+	
Indiana	+		+	
Iowa	+		+	
Kansas	+	+	+	
Kentucky	+		+	
Maine		+	+	
Maryland	+		+	
Massachusetts	+		+	
Michigan	+		+	
Minnesota	+		+	
Missouri	+		+	
Montana	+		+	
New Hampshire		+	+(c)	
New Jersey	+	+(a)	+	
North Carolina		+	+	
North Dakota				
Ohio	+		+	
Oklahoma	+		+	
Rhode Island	+		+	
South Carolina		+		+
South Dakota	+		+	
Tennessee				
Vermont	(b)		+	
Virginia		+	+	
W. Virginia	+		+	

NOTE: See note in table 1.

(a) Infrequent.

(b) Lactose neutral red.

(c) Thirty-six hours.

years and the balance now rests upon the importance of lactose broth as a better medium for an initial B. coli test. Each day brings forth another experimental factor to make the confusion greater as to the significance of lactose fracture.

The data given in table 2 show a close agreement in the laboratories as to the necessary period of incubation in the B. coli presumptive test. In the face of the almost universal choice of a forty-eight hour period, it is found in the Maryland State Department of Health laboratory that about 25 per cent of all typical B. coli isolations are obtained from those tubes which show gas only after seventy-two hours incubation. It is somewhat doubtful, with the evidence shown in table 3, whether even the apparently settled question of period of incubation is not still debatable.

TABLE 3

The effect of an increased period of incubation in the presumptive test upon the possible number of confirmatory tests

Total number of tubes incubated and giving gas = 495

GAS FORMATION AT END OF	NUMBER TUBES SHOWING GAS		PER CENT TUBES SHOWING GAS		NUMBER CONFIRMED		PER CENT OF TOTAL TUBES CONFIRMED	PER CENT OF TOTAL SAMPLES CONFIRMED
	Total	Additional	Total	Additional	Total	Additional		
hours								
24	18	18	3.6	3.6	17	17	6.2	3.4
48	263	245	53.1	49.5	197	180	66.0	36.0
72	448	185	90.5	37.4	264	67	24.6	13.4
96	495	47	100.0	9.5	273	9	3.3	1.8

NOTE: Data obtained from routine analytical determinations in laboratory of Maryland State Department of Health during a period in 1917. Presumptive tests in lactose broth. Confirmatory tests consisted of Endo, secondary lactose broth, and agar slant.

The significance of the presumptive test has been complicated recently still further by the work of Hasseltine[1] who has pointed out the importance of such details as the sterilization of media, owing to the possible breaking down of the sugars in autoclave sterilization into monosaccharides, with consequent gas production by types other than B. coli. It is clear, therefore, that the various features of choice of media, period of incubation, sterilization, and of reaction must be considered of far more importance in any future standardization than has been the case in the past.

If we subscribe, in addition, to the assumption that gas formation is not a true index of the presence of B. coli, then a unified interpretation of quality approaches still more closely the mythical pot of

[1] Hasseltine, U. S. Public Health Service Reports, Vol. 32, No. 45, November 9, 1917.

TABLE 4

Methods used in various state department of health laboratories in confirming the presence of B. coli

NAME OF STATE	MEDIA USED																REMARKS
	Lactose broth	Lactose bile	Endo	Litmus lactose agar	Second lactose broth	Gelatine	Litmus milk	Dextrose broth	Indol test	Nitrate test	Dulcite	Gram stain	Agar slant	Motility	Russells' medium	Test for anaerobes	
California	+			+	+												
Connecticut	+		+		+								+				
District of Columbia		+	+														
Florida	+		+														
Georgia	+			+	+												
Illinois	+		+		+												Presumptive test in most instances
Indiana	+		+		+												
Iowa	+		+	+													Eosine-methylene-agar for experimental work
Kansas	+	+	+		+												Add. det. infrequently
Kentucky	+		+		+												
Maine		+		+	+												
Maryland	+		+		+												
Massachusetts	+			+													
Michigan	+			+	+												
Minnesota	+			+	+							+	+	+			
Missouri	+			+													
Montana	+			+	+	+											

New Hampshire		+															
New Jersey	+		+														Usually
New Jersey		+	+		+	+	+	+			+						Infrequently
New York			+	+	+	+	+		+	+							
North Carolina		+	+														
Ohio	+			+	+												
Oklahoma	+			+													
Pennsylvania				+				+	+								
Rhode Island	+			+													
South Carolina		+															
South Dakota	+			+	+	(Bile)						+		+	+		
Vermont				+													Also lactose neutral red
Virginia		+	+		+	(Bile)											
West Virginia	+																Public supplies
West Virginia	+			+	+										+	+	Private supplies
Wisconsin				+													
Wyoming	+		+														Also bile salt agar

NOTE: See note in table 1.

gold at the end of the "standard" rainbow. In fact, when subjected to the various discriminatory tests now available to the analyst, the much maligned bacillus coli seems to emulate the historic chameleon in all its possible forms. Table 4 indicates only slightly the variations in methods of confirming the presence of the B. coli in use in various state laboratories. This ubiquitous bacterium now poses either as the "survival of the fittest," after running the gamut of several sugar fermentations, gelatine, indol, nitrate, milk, and hydrogen-ion concentration determinations, at the hands of the city health commissioner, anxious to divert criticism from a water supply by seizing upon the "fecal type" of B. coli as his measure of quality; or else it assumes the shape of the simple initial lactose fractor serving as the proud exhibit of the fortunate filtration plant operator blessed with the excellent results of operation.

What shall the standard test for B. coli include, if a mere difference in the proportions of fuchsin and of sulphite in two Endo media, results[1] in the one showing typical colonies in 75 per cent of the tubes in which the B. coli is present, while the other shows the same colonies in only 14 per cent? Shall the lactose broth, to be used in the presumptive test, contain 0.5 or 1.0 per cent lactose,[2] if the latter is detrimental to the successful isolation of B. coli? Certainly, we dodge the issue somewhat if our standard vaguely demands, for example, that the "colon bacillus should be absent in 100 cc." Why the colon bacillus? How shall we know it? How often can it occur in 100 cc. without condemning the supply? These are questions which "standards" skillfully avoid answering.

In 1907, Phelps[3] discussed a method of estimating the numbers of B. coli from fermentation tube results. His system of numerical interpretation has served, until recently, as the basis of practically all quantitative estimates of B. coli in various waters. A misconception of the method proposed at that time has been responsible in a degree for the eternal cry for standardization. The realization of the fact[3] that "the method is obviously of no value for single tests and finds its most useful application in routine studies in water purification and sewage treatment extending over long periods of time" would tend to emphasize the utility, but uncertainty, of

[2] Levine, Notes on the Presumptive Test for B. coli. Engineering Exp. Sta., Ames, Iowa, 1917.

[3] Phelps, Method for Calculating Numbers of B. coli. *Jour. A. P. H. A.*, September 30, 1907.

fermentation tube results as usually obtained, as a basis for numerical interpretation. Granting the value of establishing a maximum allowable pollution of "x" B. coli per 100 cc., we are confronted still with the difficulty of estimating such numbers from the data afforded by our present bacteriological methods.

Greenwood and Yule[4] have indicated this difficulty in a remarkably clear manner, in the following passage:

> The fact that a given volume of water tested contains no bacilli or none which will grow, does not prove that the source of supply is sterile, the point is merely that the greater the volume tested with negative results the smaller is likely to be the population of organisms existing in the supply; none of the writers has attempted to provide a scale of bacterial densities corresponding to the increase of the minimum quantity of water found sterile on examination (not strictly true*). We think, indeed, that the tenor of the passages cited (referring to various standards*) creates a presumption that the authors' criterion really is that sources *shown by other methods or found from practical experience* to be safe or to be unsafe have *usually* been found to give sterile readings when samples of the assigned size have been tested. This would explain, for instance, the lower standard adopted in the case of moorland waters. This is undoubtedly a reasonable attitude of mind enough, but it is necessary to remark that the process is not wholly satisfactory, since two observers both testing the same source on, say, the basis of a sample of 100 cc. might obtain the one a positive, the other a negative result, so that one would reject, and the other pass the supply. Further, no criterion is provided of the increase in accuracy of prediction attained when two, three or more samples of 100 cc. all give sterile readings.
>
> * Notations by Morse and Wolman.

If the so-called B. coli index is to serve as the measure of the quality of a water supply, assuming that the technique of B. coli determination has been satisfactorily settled, the necessity still remains of determining the method of obtaining the index. The number of methods now available for determining the B. coli index introduces at once further complications. Shall a proposed standard embody the procedures of Phelps,[3] Greenwood and Yule,[4] McCrady,[5] Stein[6] or Wells?[7] The method of Phelps enjoys con-

[4] Greenwood and Yule, On the Statistical Interpretation of Some Bacteriological Methods Employed in Water Analysis. *Jour. of Hygiene*, July, 1917.

[5] McCrady, The Numerical Interpretation of Fermentation Tube Results. *Jour. of Infectious Diseases*, July, 1915, Vol. 17, No. 1.

[6] Stein, Making the B. Coli Test Tell More. *Eng. News. Rec.*, May 24, 1917.

[7] Wells, The Geometrical Mean as B. Coli Index. *Science*, January, 1917.

siderable popularity because of ease of application. Unfortunately agreement as to method has not always resulted in accuracy of application. In spite of the limitations discussed by Phelps, B. coli indices are calculated indiscriminately with few or many analytical results at hand. The fact that there may be three or three hundred results has generally no effect upon the use of the B. coli index in the hands of sanitary engineer, bacteriologist, or filtration plant operator. Twenty per cent positive in 1 cc. is used with the same significance whether as a result of five or five hundred samples. The further injunction that both positive and negative results should be obtained on limiting dilutions of water is treated, in a number of cases, with the same disregard for accuracy. One of the well-known filtration plants reports, for instance, a B. coli index of 0.7066 (number per cubic centimeter), from the following results: 100 per cent positive in 10 cc. and 67.4 per cent positive in 1 cc. No tests were made on 0.1 cc. samples, the note blithely stating that such tests were assumed to be zero. That such an abuse of the Phelps' method is not a rare occurrence is evidenced by the frequent repetition of such findings as the above. Standardization of quality would hardly obviate such statistical juggling as produced by another of the largest filtration plants in the United States, which reports a B. coli content of the filter effluent of 0.44 per cubic centimeter, based upon 77 per cent and 40 per cent positives in 10 and 1 cc. dilutions respectively. Here again the 0.1 cc. samples are naively placed in the negative column on the basis of a total of 13 tests, as against 314 in both 10 and 1 cc. dilutions. Aside from justifying the theoretical basis of the Phelps method, the further establishment of allowable numbers of B. coli in a water supply would demand far more restrictions upon its use and evaluation than are observed apparently by a number of water supply workers at the present writing.

Variations in the numerical interpretation of fermentation tube results have engaged recently the attention of analysts, with resulting surprising discrepancies in data obtained by different methods. These findings illustrate only too well the weakness of establishing standards upon such meager bases, as, for instance, the "absence of B. coli in 100 cc." Observation that 50 per cent of 0.1 cc. samples have given a positive test may be interpreted as indicating a source of supply containing a B. coli content differing by over 100 per cent, depending upon the method of quantitative determination employed.

Both McCrady and Stein would assign to the above result a bacterial content of 700 per 100 cc., Greenwood and Yule a value of 690, and Phelps a value of 500, while Wells would assume the probable existence of only 317. Even a result of +100, +10, −1, and −0.1 assumes a dual rôle depending upon the judgment of the inter-

TABLE 5

Influence of method of obtaining the number of B. coli from fermentation tube results upon the apparent quality of a water

FERMENTATION TUBE RESULTS POSITIVE TEST IN CUBIC CENTIMETERS			NUMBER OF B. COLI PER 100 CUBIC CENTIMETERS	
10	1.0	0.1	Phelps method	McCrady method
16/16	14/16		88.8	200
15/15	14/15		94.0	270
16/16	11/16		71.9	115
15/15	12/15		82.0	160
13/15	5/15		38.6	24
4/4	3/4		77.5	138
4/4	2/4		55.0	69
4/4	4/4	0/4	100.0	231
4/4	1/4	0/4	32.5	35
4/4	1/4	0/4	32.5	35
4/16	0/16		2.5	3
11/15	2/15		19.3	13
12/16	1/16		13.1	12
13/15	4/15		32.9	22
15/15	14/15		94.0	270
Average number per 100 cc.....			55.6	106

NOTE. Above fermentation tube results taken from operating records (1917) of a filtration plant in Maryland. The results were obtained on the filter effluent before disinfection.

preter, for the adherent to the "reciprocal of highest positive dilution" method would find a B. coli content of 10 per 100 cc., while advocates of several of the later procedures would support the probable existence of 23 per 100 cc. A mere difference of over 100 per cent! Table 5 is of interest in illustrating the varying possibilities of interpretation of the quality of a filter effluent, with no variation whatever in the fermentation tube results obtained under actual operating conditions.

Past standards for B. coli content have shown a surprisingly patent disregard of the importance of stipulating the necessary frequency of sampling of a source before its quality may be safely postulated. *In fact no standard comes to mind at the present time in*

TABLE 6

Number of samples necessary to establish a B. coli content to within the probable errors of 5 and 10 per cent

(From Stein, *Engineering News Record*, May 24, 1917)

PER CENT OF POSITIVE TESTS IN A SERIES	NUMBER OF SAMPLES TO ESTABLISH B. COLI PER CUBIC CENTIMETER TO PROBABLE ERROR OF	
	± 10 per cent	± 5 per cent
5	1900	7600
10	900	3600
15	760	3040
20	627	2508
25	485	1940
30	365	1460
35	320	1280
30	282	968
45	235	940
50	204	816
55	190	760
60	171	684
65	165	660
70	162	648
75	155	620
80	156	624
85	160	640
90	178	712
95	210	840

which the number of samples is apparently considered of sufficient importance to warrant even a cursory establishment of a necessary minimum. In certifying a public water supply to common carriers how many state departments of health insist upon a large series of samples before passing judgment upon the analytical findings? Some of these collect samples two or three or four times a year and then certify or do not certify on the bacterial content of some 500 cc. of water out of a total consumption of millions of gallons per year. It is useless to justify such procedure upon the score that neither time nor finances are available to health officials to follow

adequately, by frequent sampling, the condition of the supply. Infrequency of sampling, with consequent inaccuracy of interpretation, is not always recognized by sanitarians as dangerous. It is for this blindness to the invalidity of findings based on essentially variable phenomena and methods that "standards" are in a measure directly responsible.

Stein[6] has pointed out within the last year the extreme importance of an adequate number of tests before any relatively precise conclusions may be projected. Table 6 contains a portion of the data developed by Stein to show the number of samples necessary to establish varying B. coli contents to within a 5 or 10 per cent probable error. In the Treasury Department standard an allowable maximum pollution equivalent to 20 per cent of all tests positive in 10 cc. is fixed. Twenty per cent was chosen, it may be inferred, in the belief that such a series of results would be comparable with a density of 2 B. coli per 100 cc. in the water. It is highly disconcerting to learn that, in order to obtain even a fair degree of precision and an approximate approach to the above number of B. coli, something like 600 samples are necessary. How meager, then, is the analytical information afforded by even 10 samples a year and how ludicrous is the certification of a doubtful supply upon the basis of only two examinations a year.

One's sense of scientific precision, and even of scientific attitude, suffers a jar when attempting to correlate the quality of a water with the data furnished in a number of other types of investigations. The pollution of streams, for instance, is studied by some governmental agency. Extensive reports are written, conclusions are drawn, correlations between the B. coli content of the stream and other sanitary features are made, and recommendations ensue. But even some of these apparently excellent researches become of little value or even misleading when the data upon which they rest have been scrutinized.

Is a pseudo-scientific correlation between B. coli content and dissolved oxygen in a stream of any importance when the number of B. coli in the stream at different stations, is obtained from one, two, or three fermentation tests? Yet table 7 is a partial list of the data culled from a recent federal report which will illustrate the derivation of unwarranted conclusions concerning the bacterial content of a stream, based upon a small number of analytical results. We must certainly question a B. coli content of 0.47 per cubic centimeter, when this quantitative index to the sanitary condition of the stream has

been obtained from only three samples. In a number of instances, too, the dilutions were not carried out far enough to give a negative fermentation test. The table loses further scientific interest when in another column the total count on agar at 37°C. is given, for a particular station, an average value of 90, a maximum of 90, and a minimum of 90, all derived from a *single* sample. It is extremely doubtful whether even a standard of utopian character would suffice to elimi-

TABLE 7

Frequency of sampling and the bacterial content of a stream at various stations

(From a recent federal report)

STREAM STATION	NUMBER OF SAMPLES	MEAN NUMBER OF B. COLI PER CUBIC CENTIMETER	TOTAL COUNT ON AGAR AT 37° C.		
			Average	High	Low
1	3	10.0	490	1160	40
2	3	46.8	630	1030	50
3	2	10.0	112	130	94
4	3	4.7	163	330	26
5	3	4.7	192	390	80
6	5	2.5	51	80	22
7	1	10.0	90	90	90
8	3	2.1	53	72	18
9	3	1.0	65	116	12
10	3	0.47	64	90	25
11	3	1.0	175	449	36
12	3	1.0	205	540	36
13	3	0.2	270	540	0

nate such data as the above. Further study of the significance of data, rather than their standardization, would be desirable. Such procedures would result, perhaps, in the abolition of haphazard stream study with bacteriological samples aggregating, at the most, five per station. It should be pointed out, too, that the above criticism is directed not so much at the failure to maintain frequent sampling, but rather at the intensive use of such data for study and for recommendation.

The method of making the B. coli examination of a single sample of water is capable of wide manipulation. The procedure in some laboratories usually consists in the inoculation of a series of fermentation tubes of different dilutions. The dilutions as a rule are in the usual geometric progression of 10, 1, 0.1, etc., cc. There does not

appear, however, to be any well-defined agreement among authorities as to the necessary number of fermentation tubes to be used at each dilution. The importance of using more than one tube at each dilution becomes manifest when it is borne in mind that Greenwood and Yule[4] have shown "that, if 'n' cc. have given a negative result, the chance of a second sample of 'n' cc. giving also a negative would be n/2n or 1/2." In other words, the chance of an inconsistency occurring when two tubes of the same dilution are used is no less than 1/2. It is clear, therefore, that too much emphasis cannot be placed upon the necessity of more than one tube at each dilution. It is of interest to note in this connection that some state department of health laboratories throughout the country recognize the value of numerous tubes, while others still use single tube determinations. Table 8 is a brief summary of the methods used in the laboratories and illustrates the wide possibility of interpretation of the quality of a supply, depending upon the laboratory in which the specimen happens to be examined. Certainly a sample of water examined in the laboratory of the State Department of Health of Connecticut may differ very materially in its supposed quality from a similar sample tested according to the methods in use in Michigan. It becomes extremely difficult, therefore, to compare types of water from different states upon the basis of percentage positive in different dilutions, when the details as to procedure are not given in complete form.

The effect of varying numbers of tubes can hardly be exaggerated, when the quality of a water is to be determined. Various refinements as to choice of numbers of tubes result very frequently in an improvement or degradation of the water in question, without any real difference in the colon content. A typical instance of such a procedure as the above is given by the method in use in a water filtration plant in Maryland. The laboratory at this plant determines the quality of its chlorinated filtered water by using a large number of fermentation tests in 10 cc., with a small number in 1 cc. In the month of June, 1917, for example, ten 10 cc., with only two or four 1 cc., samples were tested daily. The precision of results in 10 cc. was, therefore, something like twice that of the findings in 1 cc., since it varies as the square root of the number of samples. Such a system resulted in an unconscious placing of a premium on not finding B. coli in the lower dilution. Inasmuch as the quality of the chlorinated effluent, in this particular instance, was none too good, as indicated by the presumptive tests, it was distinctly advantageous, for a better

TABLE 8

Comparison of number of tubes used at each dilution in routine fermentation tests for B. coli in state department of health laboratories

NAME OF STATE	NUMBER OF TUBES USED IN DILUTION OF				
	10 cc.	5 cc.	1 cc.	0.1 cc.	0.01 cc.
California	2		2	2	
Connecticut	1		1	1	
District of Columbia	1	1	1	1	1
Florida	2		2	2	
Georgia	5		1		
Illinois	2		2	2	
Indiana	1		1	1	
Iowa	1 to 5		1 to 2		
Kentucky	1 to 5		1 to 5	1 to 5	
Maine	2		5		
Maryland	5		1 to 5	1	1
Massachusetts	1		1	1	
Michigan	7		7	7	
Missouri		1	5	3	
Montana			3 (2cc.)		
New Hampshire	3 to 5		1		
New Jersey					
Public supplies			5		
Private and new supplies			5	5	
Raw—highly polluted			2	2	2
New York	3		3	3	
North Carolina	1		1	1	
Ohio	1		2		
Rhode Island	1 to 2		1 to 2	1 to 2	
South Carolina	2		2	2	
South Dakota	3				
Vermont			1		
West Virginia	2		1		
Wyoming	2		2	2	

NOTE. See note in table 1.

showing of the plant, that the number of tubes should be reduced in the lower dilution. This was done, whether consciously or unconsciously is unimportant, with the consequence that during the month 232 tubes were used in the 10 cc. tests, while only 94 were employed in the 1 cc., or a ratio of precision in the two instances of approximately 1.6 to 1.0. The intensity of search for B. coli in the 1.0 cc. dilutions (the more important of the two under discussion) was therefore

materially reduced and the corresponding quality of the water probably enhanced. This was undoubtedly the case, since the proportion of positive tests in the 10 cc. was high (74 per cent) while in the 1 cc. it was only 7.4 per cent. It is somewhat hard to believe the data of a certain day when ten 10 cc. tubes were all found to be positive, while all of the four 1 cc. tests were negative. Here evidently the relative reduction of the number of tubes in 1 cc. from that in 10 cc. has created a less inferior quality of effluent to that probably existing. That the above conclusion is justified is inherent in the fact that, given a necessary predominance of possible negative over positive tests, or a low initial density of bacilli relative to the particular dilution, the smaller the number of total examinations the better the apparent quality of the water. In a small total number of tubes, the probability of the few possible positive tests appearing becomes very slight.

Chemical determinations. The importance of chemical examinations in determining the quality of a supply has been given considerable discussion in past years. The necessity for the so-called sanitary determinations has ranged from the viewpoint of the advocate of continuous and complete chemical analyses, as in Massachusetts, to the more radical exponents of the complete omission of sanitary chemical tests, as, for instance, the public health officials of Minnesota. The establishment of chemical standards for quality of water need not be gone into here in any detail, since both the methods and the accuracy of results in this field of water analysis are far more advanced than in the case of the bacterial tests. The problem in this instance, however, as well as in the case of bacterial standards, seems to lie more in the further study of the relative significance of data rather than in the establishment of meaningless standards based upon incomplete and variable manifestations of hidden phenomena.

Sanitary survey. Although the sanitary survey, or the study of the natural physical features surrounding a given water supply, has always been recognized as of prime importance in the consideration of the safety of a water, yet it has been rarely given the emphasis it necessarily demands in the establishment of arbitrary standards. It has been only recently that the United States Treasury Department has stipulated in its requirements that a sanitary survey of the sources of a supply should be included in the summary of the condition or quality of the water to be certified. Just what relative weight the field survey, as opposed to the bacteriological analysis, is given in the above system of standardization it is not possible to state. Pre-

cedent, too, has given far more consideration to the question of bacterial content than to any other extraneous features, with the result that, if the survey proves unsatisfactory, the layman and often the health officer of questionable honesty lay stress upon the more elusive and shadowy bacterial content. If a field survey indicates, for instance, that a water is subjected to filtration and disinfection under the guidance of the town plumber, with its attendant inconsistency of performance and continual hazard of unsuccessful purification, should or would such a survey preclude the issuance of a certificate, if the analytical data resulting from a few choice samples collected by the town authorities show the water to meet the "1/5 in 10 cc." requirement? It would seem that the artificial standard often serves the purpose of indicating the loophole through which the inefficient water company may escape, rather than of clarifying the situation as to doubtful quality.

That the general field survey has been given in the past by some sanitarians the attention it requires is undoubtedly true. Whittaker,[8] for instance, has pointed out within the last few months, as a result of a number of years of experience in Minnesota, that "the field survey and analytical results together should afford information on which recommendations can be made for the protection or abandonment of the supply." The standards of quality of water supplies should include, therefore, not only recommendations as to analytical data, but injunctions as to field or sanitary surveys. The establishment of standards as to "structural, environmental and operative features" would require,[8] in a greater degree even than similar attempts as to analytical work, an immediate standardization of method of survey rather than an evaluation of the results or findings of the survey. Here, as in the case of other possible quantitative water standards, the necessity indicates that the units of measure must be devised before the limitations of such units, as yet nonexistent, may be determined. It is the latter feature of the above axiomatic statement upon which most advocates of standards of quality lay particular stress.

PRESENT STANDARDS OF QUALITY OF WATER

State departments of health. The attitude of official sanitarians, such as those in charge of the activities of the various state depart-

[8] H. A. Whittaker, Fallacies in the Investigation of Water Supplies. *Jour. A. P. H. A.*, Vol. VII, No. 9.

ments of health, toward the advisability or necessity of the use or adoption of arbitrary standards of quality is reflected somewhat in the fact that Connecticut, Florida, Illinois, Indiana, Iowa, Kansas, Kentucky, Maine, Maryland, Massachusetts, Minnesota, Missouri, Montana, New Hampshire, New Jersey, New York, North Carolina, Rhode Island, South Carolina, South Dakota, Virginia and Wyoming use no arbitrary standard for interpretation, while California, Georgia, Michigan and Wisconsin use the United States Treasury Department standard or some variation thereof at some or all times. A number of the analysts and sanitary engineers expressed the opinion rather vehemently that no general standard could be devised to fit the peculiar conditions existing in that particular section of the country. Stephen De M. Gage, Chief of the Division of Chemistry and Sanitary Engineering of the Rhode Island State Board of Health, expresses[9] the situation with clarity in the following terms:

> We do not use any arbitrary standard of quality of water. Each individual sample is judged upon its own merits, as shown not only by the bacterial examination but by result of the chemical tests and general knowledge of sanitary surroundings by inspection of the source. It is not practicable nor fair to attempt to apply any arbitrary standard of quality, bacterial or chemical, to New England waters.

It is interesting to note in all the correspondence with the various state departments of health that the United States Treasury standard is used in practically every instance in the certification of railroad water supplies, but in only 4 of the 24 is it applied generally to others. Opinions vary widely as to the desirability of adhering strictly to the bacterial limits given in the above standard. Frank Bachman, of the California State Board of Health, states[10] that

> The Treasury Department's standards are too severe for municipal water supplies and that the 1 cc. standard used a few years ago was too low. Our arbitrary standard is between the two.

Edmon Greenfield, of the Illinois State Water Survey, agrees[11] somewhat with the above in expressing the opinion that

> In many cases we consider the standards proposed by the United States Treasury Department for water to be used on interstate carriers as just and

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[9] Stephen De M. Gage, By letter, dated November 21, 1917.
[10] Frank Bachman, By letter, dated December 3, 1917.
[11] Edmon Greenfield, By letter, dated November 13. 1917.

satisfactory. In other cases we do not feel that they apply as well as they might. The standard suggested by the United States Treasury Department for total count on agar at 37½° seems to be quite lenient, while the standard for minimum content of B. coli seems to be quite severe in some cases.

In Virginia, on the other hand, Dr. Fitzgerald, bacteriologist for the State Board of Health, assumes[12] a different attitude by pointing out that

Our standards of quality vary from those of the Public Health Service, since we allow in certain samples a count of under 500. We classify samples showing colon bacilli in 1 cc. "bad," 10 cc. and 20 cc. "suspicious."

Bearing in mind the fact that the methods of arriving at bacterial results differ widely in the various laboratories and that the arbitrary standards, wherever they exist, are interpreted with considerable differences of opinion, we should not be very far astray in concluding that "standards of quality" are not entirely favorably viewed by most of the official sanitarians. That new and impracticable standards are not only undesirable, but almost impossible of establishment at this time, also seems to be the consensus of opinion of a large part of the analysts and sanitary engineers.

United States Treasury Department standard. The power of conjuring with the name of the federal government often leads to the adoption of procedures which, under unofficial stamp, would be subjected to closer scrutiny and to more suspicion. The bare requirements of the United States Treasury Department Standard have been accepted by many as a convenient, automatic, and almost mathematical means of determining the safety of an unknown supply. Given certain known quantities of water, a few bacteriological tests, the substitution of results in an equation, and the problem was solved. The standard is apparently definite, precise, and easy of application, but does it given an accurate index to the quality of a water supply? As usually carried out, the standard undoubtedly does not. It does not perform its function as quickly, as safely, as exactly as, even today, many health officials assume.

The federal requirements stipulate that

The total number of bacteria developing on standard agar plates, incubated twenty-four hours at 37°C., shall not exceed 100 per cubic centimeter. Provided, that the estimate shall be made from not less than two plates, showing such numbers and distribution of colonies as to indicate that the estimate is reliable and accurate.

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[12] Jas. O. Fitzgerald, By letter, dated November 13, 1917.

How reliable and accurate such estimates may be is made clear by the following abstracts from a discussion[13] by Prof. Geo. C. Whipple on "The Element of Chance in Sanitation."

The chance of a single bacteriological count exceeding a given standard of 100 when the actual number present in the sample is the figure given in the first column:

NUMBER OF BACTERIA PRESENT	CHANCE OF A SINGLE SAMPLE EXCEEDING THE STANDARD OF 100
100	1 in 2
90	1 in 2.8
80	1 in 5
70	1 in 12.5
60	1 in 66.6
50	1 in 2500

On the other hand, in a sample of water which contained more bacteria than the standard, there would have been a chance that the plate contained fewer bacteria than the standard.

NUMBER OF BACTERIA PRESENT	CHANCE OF A SINGLE SAMPLE BEING LESS THAN THE STANDARD OF 100
100	1 in 2
110	1 in 2.6
120	1 in 3.4
130	1 in 4.5
140	1 in 6.1
150	1 in 7.7
200	1 in 20.0

It will be seen from these figures that in the case of waters which contain fewer bacteria than the standard, but near it, the chance of a single count exceeding the standard is high but in samples which contain much fewer numbers than the standard the chance of a single count exceeding the standard decreases rapidly. In the case of samples which contain more bacteria than the standard the chance of a single count showing less than the standard is considerable. The chance of a bad sample being called good is greater than the chance of a good sample being called bad if the number of bacteria present differs greatly from the standard.

It is evident that when dependence is placed upon a single bacterial count a rigid application of the standard is likely to do injustice either on one side

[13] G. C. Whipple, The Element of Chance in Sanitation. *Jour. Franklin Institute*, August, 1916.

or the other. It is evident, therefore, that in order to prevent injustice being done in the application of quantitative bacteriological standards to water it is necessary that several tests should be made. The number of plates which should be made in any given case has not been definitely determined, but, obviously, a large number of plates should be made whenever there is reason to suspect that the water approaches a given standard in its bacterial content. For waters which are expected to be below the standard two plates would probably be sufficient, but under many conditions five or even ten plates may be necessary to give results which can be safely depended upon.

Since the number of samples and of plates vary considerably in different applications of the United States Treasury standard, it is entirely problematical what the significance of an allowable count of 100 is when the count may be obtained through the medium of one sample or several hundred during the year.

The second criterion of the federal requirement that "not more than one out of five 10 cc. portions of any sample examined shall show the presence of organisms of the B. coli group" leads one into further complications, when it is kept in mind that it was the intent of the standard to allow a possible maximum B. coli content of only 2 per 100 cc. The 1/5 in 10 cc. requirement was assumed to give a convenient method of testing the allowable "2 per 100 cc." content. How successfully it may succeed in doing this may be gathered from the following discussion[5] by McCrady.

Some calculations indicating the percentage of various results which will occur when various numbers of B. coli are contained in the sample, are shown below.

NUMBER OF B. COLI IN SAMPLE X	PERCENTAGE OF TIME THAT "0/5 IN 10 CC." WILL OCCUR	PERCENTAGE OF TIME THAT "1/5 IN 10 CC." WILL OCCUR	PERCENTAGE OF TIME THAT "2/5 IN 10 CC." WILL OCCUR
0	100.0	0	0
1	50.0	50.0	0
2	25.0	55.0	20
3	12.5	45.0	36
4	6.25	33.55	
5	3.13	23.26	
6	1.56	15.52	
7	0.78	10.09	
8	0.39	6.44	
9	0.19	4.05	
10		2.54	
11		1.57	

It will be noticed from these calculations that when 4 B. coli are present in the sample, the sample will pass the standard about 40 per cent of the time. And one out of about every six samples, containing 6 B. coli, will pass the standard (1.56 per cent plus 15.52 per cent). On the other hand, one out of every five samples containing only 2 B. coli per 100 cc. will fail to pass the standard.

Consequently, when it is remembered that the standard signifies a most probable limit of 2 B. coli per 100 cc., it is evident that the standard method of analysis renders the standard much more lenient than might, at first glance, be supposed.

The above discussions illustrate the possible defects of the Treasury Department standard when the requirements are literally followed. Since no complete directions are given as to method, frequency of sampling, or interpretation of the analytical procedures outlined, the possible variations in significance of the standard become manifest. The standard becomes, therefore, not a precise and accurate index as to quality, but rather simply a convenient mode of analysis to be used with considerable caution for comparative purposes.

A rather curious abuse of the federal standard has resulted in recent years from the failure of the requirement to specify the exact and relative importance of the somewhat "delphic utterance" that "it is recommended, as a routine procedure, that in addition to five 10 cc. portions, one 1 cc. portion, and one 0.1 cc. portion of each sample examined be planted in a lactose peptone broth fermentation tube, in order to demonstrate more fully the extent of pollution in grossly polluted samples." Inasmuch as the requirements suggest the 1 and 0.1 cc. tests, but make no stipulation as to their relative significance, it becomes extremely convenient for health authorities, water companies and filtration plant operators to discard the lower dilutions whenever the results in 10 cc. meet their purposes better. It should be borne in mind that unfortunately the aim of some who operate water supplies is not always to determine the real quality of the supply, but to defend it, in the face of criticism, by endeavoring to show, through judicious selection of data, that the water passes the standard of the United States Treasury Department.

A striking illustration of such a procedure is given by the situation in one of the cities in Maryland. The municipal supply is not always of the best and controversial discussion as to quality has occurred from time to time between state and municipal health authorities. The question of certifying to the supply is still a source of disagreement, simply because of the vagueness of the federal requirements.

A municipal official may insist upon the selection of a short series of good results that may have occurred just prior to the date for certification, when these results are not typical of those obtained during the rest of the year, or upon the strict application of the 10 cc. criterion, in the face of contradictory evidence given by lower dilutions. A discussion of the data shown in table 9 will make the situation clearer. In this table there have been collected the results of labora-

TABLE 9

Significance of 1.0 and 0.1 cc. dilutions in determining the quality of a supply by the United States Treasury Department standard

1917 MONTH	B. COLI PER CENT POSITIVE CONFIRMED IN			B. COLI PER 100 CC. (BY PHELPS' METHOD)
	10 cc.	1 cc.	0.1 cc.	
January	20.5	6.4	0.6	13.21
February	61.9	26.5	6.2	
March	26.3	9.0	3.2	39.53
April	16.7	3.6	1.4	17.51
May	26.7	9.3	0.7	17.34
June	33.3	15.1	2.4	38.52
July	26.8	15.7	6.3	73.51
August	26.0	12.0	2.0	31.40
September	39.0	10.0	1.0	21.90
October	18.0	2.1	0.0	3.69
November	24.3	0.0	0.9	11.43
December	9.9	2.0	0.0	2.79

Average B. coli index, from 10 cc. results only = 2.43 per 100 cc. (exclusive of February).

Average B. coli index from 10, 1 and 0.1 cc. dilutions = 24.62 per 100 cc. (exclusive of February).

NOTE. Above results obtained from tap water analyses in city in Maryland. Average number of samples approximately 125 per month.

tory examinations extending over the year 1917. By averaging only the 10 cc. results for the year and estimating from these the number of B. coli per 100 cc. (by Phelps' method), we obtain an average B. coli content of 2.43 per 100 cc. This value is somewhere near the maximum allowable density usually assumed as the requirement of the Treasury Department. When using the additional results of 1 and 0.1 cc. dilutions, the quality of the water takes on an entirely different aspect. The average number of B. coli per 100 cc. (also calculated by Phelps' method) now becomes 24.62, or over ten times

the value obtained from the 10 cc. dilutions alone. The city health official would support his contention as to certifiability upon the 10 cc. basis while ignoring the much less attractive 1 and 0.1 cc. results.

In the month of April, for instance, the water, on the basis of the 10 cc. figure, would meet the certification requirement. Yet, by using all the data available, the B. coli content of the water may be assumed to be 17.51 per 100 cc. If the 1 and 0.1 cc. dilutions had not been made, as is often the case, the doubt as to the superior quality of the supply would have been removed, in spite of the fact that the water contained approximately nine times as many B. coli as is tacitly allowed by the federal requirements.

The above data and their application are not at all hypothetical, but are exact and accurate duplicates of conditions which have occurred in Maryland, and probably in other states, as a result of the compulsory adoption of exact standards and their adaptation to variable phenomena. In such instances, the application of the standard aids the official to dodge the responsibility of producing water of excellent quality, instead of serving as the means of detecting poor quality.

It is well to point out, before leaving the discussion on the federal standard, that, if any changes are contemplated in its requirements emphasis must be placed upon the necessity of using all the data extending over the periods intermediate between the official certification dates, rather than a few choice samples collected just prior thereto. Too often a large series of earlier results are discarded for more convenient later data. It comes about, therefore, that the present federal requirement may assume a two-fold aspect depending upon the whim of the water supply administrator. Incidentally, haphazard certification to the Treasury Department by local health officials, who are frequently over-zealous, should be stopped and this duty delegated only to the state health organizations.

Filtration plants. The analytical methods in use at the various filtration plants throughout the country have been made the subject of an extensive and detailed compilation within recent months by Jack J. Hinman, Jr., of the Iowa State Board of Health. Mr. Hinman has gathered such complete data on this subject that it would be entirely unnecessary to discuss here the procedures further than to quote from one of his discussions[14] the following words:

[14] J. J. Hinman, Jr., Water Works Laboratories. *Iowa Academy of Science*, Vol. xxiv, 1917.

A glance at the table will show you that in spite of the excellent work which has been done in the preparation of our Standard Methods of Water Analysis, the bacteriological procedure of the water plants is far from uniform.

It seems, therefore, that the possibilities of obtaining definite units of measure of quality for filter plant effluents are as remote as those for general water supplies.

It is of passing interest to note at this point several deleterious effects of the past standardization of filter effluents upon an accurate interpretation of quality. One of the oldest methods of rating filtration plant performance, in reality sometimes resulting only in a specious attempt to conceal by circuitous methods the quality of an effluent, is the familiar "percentage efficiency" method. Its basis, its shortcomings, its dangers, even today, have been elaborated time and again, but the "percentage efficiency" still persists as the old "war horse" blinder for inefficiency and poor effluent.

Attention is called here only briefly to another practice which has come to the author's attention in the use of the above method, resulting in an added objection to the formation of reckless standards which years do not serve to obliterate from the minds of the gullible public. The average percentage removal of bacteria during a particular month means to most laymen the usual or mean removal effected during individual days. If this average figure happens to reach 98, then all is well in the heart of the consumer, if not in the mind of the health officer. If this method of standardization is to be used, its mathematical evaluation should be, at least, properly developed. Strange as it may seem, the practice has persisted in two of the filtration plants in Maryland of summing up the total raw water and effluent bacteria for the month and calculating from these totals the average monthly percentage removal. This resulted, for example, for one step of the purification process, in a figure of 77.0 during a month in which more than 40 per cent of the days show a percentage removal of 47 or under, while at no time during the month did the removal exceed 93 per cent.

The obvious effect of calculating average percentage removals by means of total bacteria for the month is to vitiate the poor results of many days by good results on a few. The ordinary and real operating results of the plant are totally lost sight of. This effect is made clear by the following series of results from the plant under discussion

June 18–23, bacterial removal, coagulating basins to filter effluent

DAY OF MONTH	AVERAGE COUNT, 20°C.		PER CENT REMOVAL
	Coagulating basin effluent	Filter effluent (Unchlorinated)	
June 18	1355	160	88
June 19	295	210	29
June 20	135	85	37
June 21	1280	146	89
June 22	130	124	5
June 23	285	180	37
Totals	3480	905	285

Average percentage removal—by Method (a), 74.0
by Method (b), 47.5

The percentage removal designated (a) is the value obtained by the method in use at the plant, consisting of the percentage change in the total numbers of bacteria for the week. This value is recorded, then, as the average percentage removal, in spite of the fact that on four days out of the six the performance was nowhere near 74.0 per cent. It is manifest from the above data that two excessively high basin counts hide completely, in method (a), the poor results obtained during two-thirds of the week. The undue influence of a few high raw water counts is accentuated, due to the fact that they are almost always accompanied by high percentage removals (for instance, June 18 and 21). A few days, or even one day, of high raw water counts may predetermine the value of the percentage removal for a whole month. Table 10 is exhibited in this connection, since it illustrates the possibilities of statistical juggling even with such an apparently stable and uniform procedure as the calculation of percentage removal. In explanation, it should be pointed out that method (b) consisted of obtaining the average of the *daily percentage removals* (as stipulated in the report of the committee of the New England Water Works Association, January 13, 1915) rather than the percentage removal of the total raw water and effluent bacteria. In a discussion of the average performance of a plant, the individual daily performances are dealt with, since the *performance*, not the bacteria, is under scrutiny.

The above discussion illustrates the abuses to which a standard or unit of measure may be subjected when the mode of determining

the unit has not been defined in iron-clad terms; and, secondly, it illustrates a fallacy which has not always been kept clearly before us, that is, that a measure of performance, whatever its method of

TABLE 10

Comparison between average percentage removals obtained by two different methods of calculation

MONTH		PERCENTAGE REMOVAL						
		Turbidity			Bacteria at 20° C.			
		Basin 1	Basin 2	Filters	Basin 1	Basin 2	Filters	Chlorine
January	Reported	73.5	76.0	94.5	75.0	77.0	94.5	93.0
	Revised	50.0	53.0	95.5	53.0	48.0	93.8	90.5
March	Reported	89.5	90.5	96.7	86.0	87.0	75.0	97.0
	Revised	77.2	80.4	97.7	80.0	83.0	71.7	95.6
April	Reported	79.0	79.0	100.0	84.5	82.5	88.5	91.0
	Revised	76.2	77.1	100.0	78.0	71.2	88.8	73.3
May	Reported	78.0	79.0	100.0	71.0	61.0	66.0	92.0
	Revised	76.3	77.4	100.0	70.0	53.0	57.0	66.0
June	Reported	87.0	98.0	98.5	88.0	86.0	80.0	71.0
	Revised	76.0	78.1	98.1	74.7	73.0	67.8	63.2
July	Reported	89.0	92.0	100.0	84.0	82.0	69.0	78.0
	Revised	77.9	81.7	99.3	64.0	60.9	64.0	52.0
August	Reported	71.0	73.0	96.0	59.0	37.0	62.0	93.0
	Revised	69.4	67.3	97.3	42.3	21.0	54.5	86.5

NOTE. *Reported* results calculated by Method (a)—see text.
Revised results calculated by Method (b)—see text.
Reported results taken from records of a filtration plant in Maryland. The percentages are calculated for successive steps of the purification process.

calculation, is not synonymous with a measure of the quality of an effluent. It may frequently happen that the unit of performance may be so chosen as to give an index to the quality of the effluent, but the same objections cannot be raised to standards of performance as to those of quality. In the former, comparative data may always be used in the study of the functioning of a plant, regardless

of their peculiar significance, but in the latter, the significance of absolute, and not relative, values is to be considered.

SUMMARY

The establishment of a standard of quality for potable water means the setting up by some accepted authority of a rule for the measure of quality. Since quality is a variable attribute, intricately dependent upon a series of natural physical, chemical and biological phenomena, its measurement becomes extremely difficult. The quality of a particular water cannot, in most instances, be measured adequately by means of the evaluation of only one of its characteristics. The real consideration or interpretation of the potability of a supply involves a series of mutually active attributes, each of which plays a part of importance in modifying and determining the character of the water. Any scientific and practical standard must include, therefore, a composite of all those features which influence a change in quality. The single ultimate unit of measure or the final standard becomes, in this way, an index number of properly weighted individual and fundamental units.

The prime requisites for the establishment of any standard are the existence of those basic units which are to be its components and of universal agreement as to the relative significance of such components. In the field of water supply neither of the two above requirements has been fully met. Basic or fundamental units for measurement of quality have not been established with any degree of exactness or accuracy. A unit of measure, such as the B. coli content, certainly cannot be predicated upon such variable procedures as are now followed, without resulting in a confusion of interpretation. The establishment of any unit demands an absolute consistency in its measurement. It is this consistency of measurement which is now absent in practically every available measure of quality.

If inconsistency reigns in the determination of the fundamental units, such as the total count, the B. coli content, the chemical constituents and the sanitary survey, then the general standard of quality, a derived unit composed of basic measures, becomes of extremely little value. If we add to this consideration of inconsistent method of obtaining individual units the fact that their relative significance is still unsettled, then a general standard becomes practically useless and even misleading.

From the above discussion, it becomes clear that the study of the *method* of evaluating a unit must of necessity antedate the attempt to establish *limiting values* of such a unit. A critical survey of past standards of quality seems to indicate an assumption that the method of unit-evaluation is fixed, and therefore that limiting values are the desiderata. It is not felt that the status of laboratory or field method of analytical examination warrants any such assumption. The field for future standardization of quality of water supplies would appear to lie more immediately in the consideration of such problems as the relative significance of different bacterial counts, the methods of obtaining the counts, the necessary frequency of sampling, of plating, of numbers of fermentation tubes, the numerical interpretation of usual fermentation tube results, the allowable variations from specified bacterial contents, the determination of real bacterial indices to sewage pollution, the importance of chemical determinations, and the standardization of field survey method. More remotely, the problem of standards is concerned with the coördination of the results of such studies as the above in such a way as to construct a composite unit of measure. Until these studies have been made and a general agreement reached, a standard would have but little value.

WATER SUPPLY AND SANITATION AT GOVERNMENT CAMPS AND SHIPYARDS[1]

By Samuel A. Greeley

The author has been connected during the past year with sanitary work for the Government in three different capacities, first, for cantonment construction; second, for the Public Health Service, and third for the Emergency Fleet Corporation.

It has been interesting to see the extent of this activity and the amount of work that is being done.

The water works, sewerage system and other utilities at Camp Custer are in charge of Major T. A. Leisen, President of the American Water Works Association. The author was there in the first part of January when an interesting phase of the work was the water consumption. The consumption on which the design of the system at each cantonment was based was 55 gallons per capita per day. Camp Custer was using 60 to 65 gallons at the time of the author's last visit. From 45 to 75 gallons is the range at the cantonments of which the author has records, and there is a tendency to increase rather than decrease the amount. Some of the cantonments have sewage treatment plants and these are being operated with great care; so much so that the author feels that the field of sewage works operation will receive an impetus from the results obtained in the operation of the cantonment plants. Officials in charge of them compare notes and thus gain by the combined experience of the operators at all camps.

The United States Public Health Service is an old organization which has recently expanded its sanitary division, which is now very well fitted to take up the work of sanitation in the cantonment zones. Where the Government has built large cantonments, it has established zones around them and has taken charge of the sanitary activities within those zones. The zone in Louisville is perhaps the most important because one of the army cantonments touches the city, which thus comes within the cantonment zone.

[1] Read before the Illinois Section at Urbana, April 16, 1918.

The Public Health Service sent two men of medical training to Louisville in October, about the time the troops began to arrive there. They established themselves on a coöperative working basis with the city and county health officers. They got things done that had been talked about as being necessary for many years. They actually built over 500 sanitary privies within a few miles of Camp Zachary Taylor. Almost every farm was fitted with a flyproof sanitary privy. In addition, they took up the restaurant question and the physical examination of employees in restaurant kitchens.

The author had been working on the garbage and refuse disposal problem in Louisville during 1917, and at the time the Public Health Service stepped into the work there, things were nearly ready to develop into some action. A beginning had been made on ordinances to organize a collection department, to improve conditions on the dumps and to provide for garbage disposal. The Public Health Service obtained a man who was familiar with the town and put him in charge of the collection work. Now they are subdividing the town into districts and establishing a model collection service in different parts of the city, with the idea that the city will extend this service over the whole city. The program calls for the separation of ashes and rubbish from the garbage. From the districts, ashes and rubbish are taken to a dump, which is run as a model. A part of the garbage is taken to a hog farm, also under the supervision of the Public Health Officers, and a part to a rendering plant. They are thus doing work that will be of permanent value to Louisville and of much value to other communities.

For ship construction under the Emergency Fleet Corporation the country is divided into eleven districts, extending along the Atlantic, the Pacific, the Gulf and the Great Lakes. Last November the Department of Health and Sanitation was established under the direction of Lieutenant-Colonel P. S. Doane. He contemplates, as soon as he can, placing a sanitary engineer in each of these shipping districts. The work has the following three objects:

1. The actual condition of the yards, to see that there is nothing which may create sickness among the men.

2. The environment and conditions; to see that health conditions in the towns where the men live are good.

3. To see what the local and state health departments are doing and where they can be assisted.

The work taken up by this Department of Health is first medical and concerns accidents. It promotes the establishment of small hospitals and dressing rooms, with nurses and doctors in attendance. In some yards there are physical examinations of the men to see that they are not likely to bring disease into the yard. Cases of illness are followed into the homes, to be certain they are handled as wisely as possible.

The next thing is sanitation, and the methods can be best explained by examples of conditions in some of the western yards. In Washington, Oregon and California there are about 50 shipyards. In Washington and Oregon there has been a tremendous increase in the lumber activities. Many towns in these states have gone as far as 25 miles distant to get their water supplies. They now find themselves suddenly faced with the danger resulting from camps of 400 to 500 men on the drainage areas, which are very likely to make trouble with their water supplies. In some of the yards of California, the mosquito problem is very important. In the yards near the city of Los Angeles last summer it was necessary to maintain smudges to keep off the mosquitoes. Work has already been started on that problem. We find many instances where the Federal Government, in its effort to maintain healthful conditions at the shipping yards, can effectively coöperate with the local authorities. In some parts of the West where fishing is carried on extensively, there is a great fly problem and flies are not only thick enough to be a nuisance, but in the restaurants and eating places a real danger. Many of the ship yards located at a considerable distance from restaurants, have had to furnish their own lunch rooms and some of them have not yet developed their sanitary systems sufficiently to meet the fly problem.

The department of health and sanitation goes into the matter of housing. It does not have jurisdiction over additional new houses but takes up the question of sanitation in existing houses. For instance near some of the large works in San Francisco the lodging houses near the ship yards are not properly maintained and the men can not get proper lunches. The city and state departments of health feel that with the coöperation of the Emergency Fleet Corporation improvements of a permanent nature can be accomplished. The question of light and heat also comes into the field of the department of health and sanitation.

SANITARY ASPECT OF THE WATER SUPPLIES AT THE ARMY CANTONMENTS[1]

By Lieutenant-Colonel James T. B. Bowles, N.A.

One of the duties of the Sanitary Corps has been the supervision of the quality of water supplies at the various cantonments.

The water requirements of the cantonments, both from the standpoint of quality and quantity, have been anticipated by the Cantonment Division of the Quartermaster Corps remarkably well. No source has been so inadequate that there was such danger of shortage that it had to be supplemented by additional sources;—no source was questionable from the sanitary standpoint to the extent that its use was prejudicial to health.

In the development of the water supplies, purity was not lost sight of. Construction Quartermasters at the various cantonments were given blanket authority to purchase chlorinators. This was done in practically all cases, either one or more chlorinators being installed.

The development of supplies for the cantonments has been along the following lines:

(a) Purchase of water from municipalities where the camp was located within a reasonable distance from city and where the municipal plant had facilities to assume the additional load.

(b) Development of a special supply,—a ground water supply where there was knowledge of water bearing strata, and where the cost of obtaining it was not prohibitive.

(c) Lastly, development of surface supplies, supplemented by a purification process where necessary.

Of 31 National Army and National Guard camps, 18 are supplied with water from municipal systems. Twelve of these are surface

[1] "Permission to publish the inclosed article, entitled 'Sanitary Aspect of the Water Supplies at the Army Cantonments,' by Lieutenant Colonel James T. B. Bowles, is granted as requested.

"By direction of the Surgeon General:

James W. Van Dusen,
Colonel, Medical Corps, N. A."

Presented at the annual convention at St. Louis, May, 1918

supplies, demanding such purification as will insure at all times a clear, colorless and sanitary water. Six are ground waters, requiring no purification, with possible exception of chlorination more as a prophylactic than a necessity. Most of these municipal systems have been found amply large enough to assume the demands of additional consumption without increased plant development.

Fourteen supplies were developed by the Cantonment Division; only three of these were surface supplies.

One of these surface supplies utilizes water from a sparsely inhabited water shed, and as a sanitary precaution no other purification is necessary than chlorination. The other two are from polluted streams and require purification.

Of the ground water supplies developed, none required purification other than chlorination.

In the case of the western camps, where ground waters are used, softening for boiler and laundry purposes has been considered advantageous.

Supervision of quality of water has been conducted on the following lines:

(a) Inspection of municipal plants.

(b) Arrangements whereby frequent bacteriological examinations of all sources could be made.

The inspection of municipal plants revealed many interesting conditions. In many cases a modern up-to-date plant, supervised by live officials with a sense of the necessity of pure and wholesome water; but in too many cases, plants operating with a low margin of safety, and under the control of operators who had little knowledge of the kind of water the plant was turning out.

The inspection resulted in either assisting the city to secure competent men to supervise operation or to make arrangements whereby an officer of the Sanitary Corps would assume responsibility for the quality of the water.

Some authorities gladly and willingly coöperated in carrying out the improvements and changes recommended. Others reluctantly admitted that the quality of their water supply was not above suspicion. This latter class was usually the short-visioned, non-informed type of citizen, whose ideal of the best fulfillment of his position was in keeping a tight clutch on the purse-strings.

From the beginning of the cantonment activities, an effort was made to secure accurate bacteriological data concerning the various

Water supplies at national guard camps

CAMP	MUNICIPAL SUPPLY	DEVELOPED BY CANTONMENT DIVISION	CHARACTER			PURIFICATION PROCESS							REMARKS
			Ground water	Surface water		Plain sedimentation	Chemical treatment	Coagulation	Filtration		Chlorination		
				Impounding reservoir	River				Pressure filters	Mechanical gravity	Liquid chlorine	Hypochlorite	
Beauregard		yes	yes										
Bowie	yes			yes*			yes	yes		yes	yes		* West Fork, Trinity River. Water slightly hard at times. Considerable turbidity
Cody	yes		yes										Unquestionable purity. Fairly hard. Artesian wells
Doniphan	yes			yes*			yes[1]				yes		* Lake Lawtonka. Trouble from heavy algal growths
Greene	yes				yes	yes	yes	yes		yes	yes		Catawba River. Soft water. Considerable turbidity at times
Hancock	yes				yes	yes	yes[2]			yes	yes		Savannah River. Soft water. High turbidity at times
Kearny[3]	yes				yes	yes	yes		yes		yes		San Diego River. Soft water, slightly colored, variable turbidity
Logan		yes	yes										
McArthur	yes		¾		¼*		yes	yes		yes	yes		* Brazos River. Treatment applies to river water only

McClellan	yes		yes										
Sevier	yes			yes*			yes[4]		yes		yes		* Source, mountain springs.
Shelby		yes	yes										
Sheridan	yes		yes*										* Artesian wells
Wadsworth	yes		yes			yes	yes	yes		yes	yes		
Wheeler		yes[5]			yes*		yes		yes		yes		* Stone creek
	yes				yes*		yes	yes		yes	yes[6]	yes	* Ocmulgee River

[1] Copper sulphate twice monthly.
[2] Alum applied to water entering sedimentation basins, during high turbidity.
[3] Artesian wells in River Bed, used as emergency supply.
[4] About one-third of water from an isolated reservoir, treated with alum and passed through pressure filters.
[5] An emergency supply and used until camp had been connected to city mains.
[6] City water is chlorinated before entering camp distribution system.

Water supplies at national army camps

NAME OF CAMP	MUNICIPAL SUPPLY	DEVELOPED BY CANTONMENT DIVISION	CHARACTER OF SUPPLY			PURIFICATION PROCESS							REMARKS
				Surface water					Filtration		Chlorination		
			Ground water	Impounding reservoir	River	Plain sedimentation	Chemical treatment	Coagulation	Pressure filters	Mechanical gravity	Liquid chlorine	Hypochlorite	
Custer		yes	yes				yes[1]				yes		A relatively hard water, 250 p.p.m. $CaCO_3$. Unquestionable purity
Devens		yes	yes									yes[2]	Water has been exceptionally good despite evidences of pollution
Dix		yes			yes*						yes		* Rancocas Creek. Highly colored, high free CO_2 free vegetable acid in small amounts
Dodge		yes	yes								yes		A hard water. Original purity unquestionable
Funston		yes	yes								yes		A relatively hard water
Gordon	yes				yes*	yes	yes[5]	yes	yes		yes		* Chattahoochee River. A soft water highly turbid at times
Grant		yes	yes								yes		A hard water. All boiler water softened
Jackson	yes				yes*	yes	yes[5]	yes		yes	yes		* Congaree River. A soft water, highly turbid at times. Polluted
Lee	yes				yes*	yes	yes[5]	yes		yes	yes		* Appomattox River. A soft water, highly turbid at times. Polluted

Lewis		yes	yes										
Meade		yes			yes*		yes[5]	yes		yes	yes		* Little Patuxent River. A soft water. High turbidity, varying with rainfall. Relatively polluted
Pike	yes				yes[3]*	yes	yes[6]	yes	yes[4]			yes	* Arkansas River. A very turbid water, and relatively hard at times. Polluted
Sherman		yes	yes								yes		
Taylor	yes				yes*	yes	yes[5]	yes		yes	yes		* Ohio River. A soft water, highly turbid at times. Polluted
Travis	yes		yes								yes		
Upton		yes	yes										

[1] Water for all heating systems and laundry softened.
[2] For emergency use. During winter several breaks occurred in well casing.
[3] Artesian well water used when chlorine in river water goes above 400 p.p.m.
[4] About four-fifths of the plant is pressure filters.
[5] Alum and lime treatment.
[6] Iron and lime treatment.

supplies. Prior to any definite knowledge of the potability of these supplies, it was assumed that they were all more or less polluted, or at least there was potential pollution and facilities for chlorination were installed.

In this the department had the coöperation of the manufacturers of the apparatus for applying liquid chlorine, who gave prior consideration to all Government orders. Analyses were made at the Army Medical School, Washington, D. C., and the Departmental Laboratories of the U. S. A.; by the Red Cross Units and the Public Health Service, and at the base hospital laboratories connected with the various camp hospitals.

In the early period of the camps, semi-weekly samples were collected and forwarded by express or mail to the nearest Government laboratory. Where the results of the analyses showed contamination, the camps were immediately informed by telegraph. The means of protection was chlorination, and where this was not possible an order was issued to boil all drinking water.

In the extra-cantonment areas, the U. S. Public Health Service included examination of water supplies in their routine work. This was of great assistance in checking up the operation of municipal supplies. A great many of these municipalities had no analytical data on their water supplies; furthermore there seemed to be no tendency on the part of the various State Boards of Health to exercise supervision or control. Where analytical data were available the interpretation corresponded to numerous and varied standards.

The standard of the Treasury Department as applied to interstate carriers was early adopted as the standard of water supplied to the cantonments.

In the early period of the camps, considerable apprehension was caused by the results of the analytical tests, which in many cases indicated gross pollution. This could be accounted for only as a result of construction. This pollution was in most cases temporary and gradually disappeared with continued use of wells and distribution systems.

Since the base hospital laboratories have been equipped, bacteriological analyses of water are now a part of the daily routine.

The results of sanitary water and typhoid prophylaxis have resulted in a remarkably small number of cases of typhoid and related diseases among the troops at the camps. From September 14 to

April 26, there have been 123 cases of typhoid with seven deaths, 315 cases of dysentery with one death.

What quota of these cases is attributable to water it is impossible to say.

Several of the typhoid cases developed in the early part of September and may have had their origin in civilian communities.

In conclusion the author would state that liberal application of chlorine, with close laboratory control and supervision, has resulted in a pure and wholesome water being supplied to the camps at all times.

LOSS OF HEAD IN CORPORATION COCKS AND SERVICE PIPES[1]

By Bernard J. Bleistein

Several years ago a series of tests was made by the Bureau of Investigation and Design of the Department of Water Supply, Gas and Electricity, New York City, to determine the losses of head in corporation or service cocks and service pipes. The results of these tests may prove of value to the water works profession, particularly the tests of corporation cocks, there being very little data available on that subject. All sizes in use by the department at that time were tested. Of the two largest sizes four of each type were tested and of the smaller sizes, two of each type. Of the lead and galvanized service pipes four lengths of each size about 15 feet long were tested.

The observations were very carefully made, the losses being measured by mercury deflections, and the discharges by a 2-inch meter of the current type. This type was selected rather than a meter of the disc type, as the flow through the latter caused considerably more vibration and fluctuations of the mercury deflections than a meter of the current type. The same meter was used during the entire series. It was rated on a testing machine at the beginning and end of the tests, the exact discharge at the various rates being determined by weighing.

The corporation cocks were inserted in a length of 12-inch cast iron pipe, capped and plugged at the ends, by a tapping machine in the usual manner. The main was connected to a fire hydrant through the plugged end by means of a short piece of 4-inch galvanized iron pipe. The cocks were set about a foot apart, the 2-inch cocks being set nearest the capped end of the pipe in order to eliminate any uncertainties due to swirls at the high rates of flow.

New lead pipe of a size corresponding to the size of the corporation cock and of double A weight was connected to the tail piece with the

[1] Read before the St. Louis Convention, May 16, 1918.

usual form of wiped joint. The meter with a control valve at the outlet end was connected to the other end of the lead pipe. The galvanized pipe was connected in a similar manner. Both the lead and the galvanized iron pipe were of the usual commercial sizes, the galvanized being of standard weight. The lengths were selected at random from a large stock. The lead pipe was handled more carefully than such pipe is usually handled in order to prevent denting or needless bending of the pipe.

In measuring the losses through the corporation cocks, a U-tube partly filled with mercury was used. One leg was connected by means of rubber tubing to a $\frac{1}{4}$-inch opening in the top of the main, and the other to a $\frac{1}{16}$-inch opening in the wall of the lead pipe one foot from the end of the tail piece. The rubber tubing and the upper half of the U-tube were completely filled with water. The loss measured included the velocity head, entrance head, and the frictional losses through the cock and 1 foot of lead pipe. This total loss was high, and at the high rates of flow it was necessary to connect three tubes in series, the loss being the sum of the deflections in each tube.

The losses in the pipe were measured in a similar manner, the two legs of the U-tube being connected to $\frac{1}{16}$-inch openings, 2 and 4 feet apart. Tee connections were provided at the different openings and it was thus possible to measure the losses in the corporation cock and the various sections of each length simultaneously. The sum of the losses in the various sections was used in computing the unit loss for each length.

Some difficulty was experienced at first in preventing the formation of a burr on the inside surface of the lead pipe in drilling the holes through which the pressures were transmitted. This was finally overcome by punching the holes through the walls from the inside in the following manner: Two $\frac{1}{8}$-inch holes were drilled partly through the walls of the pipe on points diametrically opposite, and one of them continued as a $\frac{1}{16}$-inch through the wall. By inserting a piece of solid drill rod through this opening, the opposite wall was punched through, leaving the inside surface quite smooth. The burr around the inside of the drilled hole was removed as much as possible with a special tool, and the hole plugged up and soldered. After the tests were completed, the pipe was cut open at each of the holes and the inside surface examined. In only two cases was a burr found and in both it was very slight.

A single $\frac{1}{16}$-inch hole was drilled through the wall of the galvanized iron pipe at each pressure point, using a high speed drill. A small burr was formed but no attempt was made to remove it, it being felt that this burr would not affect the results materially as the inside surface was already quite rough.

In taking the readings three observers were used, one to read the meter, the others to note the U-tube deflections. At each rate of flow a sufficient quantity of water was allowed to pass so that the dial hand on the meter made a complete revolution. In this way any errors due to eccentricities of the dial hand or inaccuracies in the graduations were eliminated. The time was taken with an ordinary watch, readings being taken to the nearest half second. As the total time for any individual test was never less than two minutes, the resulting error was probably less than 1 per cent. A stop watch was tried but failed to give satisfactory results as it did not always start on being released. The deflections were read at 15 second intervals, the readings being taken to the nearest $\frac{1}{16}$ inch. As no deflection was less than 1 inch and at least eight readings for each rate were taken, the resulting error is probably also well within 1 per cent. The mercury in the tubes fluctuated slightly, due to changes of pressure in the main, but these fluctuations were never more than 2 per cent of the total.

After a sufficient number of tests had been made on each length, the unit losses at the observed rates of flow were computed, 1 inch of mercury deflection being equivalent to 1.047 feet of water. These values were substituted in the Williams & Hazen formula,

$$v = c\, r^{0.63}\, s^{0.54}\, 0.001^{-0.04}$$

and the average value of c for each length obtained. From these the average value of c for each size was computed. The values of c for the same section of pipe at different rates of flow showed very little variation, the extreme varying not more than 3 per cent from the average. For different sections of the same length of pipe, however, the variation was considerable, even in the case of the lead pipe. Table 1 shows the average value of c obtained from these tests, the range in the value of c for different sections of the different lengths, and the range in the average value for the different lengths.

The diameters given are those ordinarily used in connection with lead and galvanized iron pipe, and are not the measured diameters

of the actual lengths tested. Unfortunately the actual diameters are not available. The greatest variation would be expected in the

TABLE 1

Results of tests on lead and galvanized iron pipe

SIZE	DIAMETER	RANGE OF DISCHARGE	RANGE IN VALUE OF c		MEAN c
			2 ft.–4 ft. lengths	15 ft. lengths	
			Lead pipe		
inches	*inches*	*gallons per minute*			
½	0.50	2–16	130–155	144–150	148
⅝	0.625	2–22	140–165	147–157	152
¾	0.75	5–50	120–148	124–143	137
1	1.00	10–80	121–140	131–138	134
1½	1.50	20–200	120–149	138–143	139
2	2.00	60–300	140–170	157–162	160
			Galvanized iron pipe		
½	0.623	2–18	78–110	92–97	94
¾	0.824	5–50	88–125	97–104	101
1	1.048	10–80	100–125	106–110	109
1½	1.611	20–200	95–115	101–105	103
2	2.067	60–270	80–125	98–103	101

galvanized pipe. Subsequently four lengths of each size of the galvanized pipe were measured by filling with water and the average diameter computed, with the result shown in table 2.

TABLE 2

Actual inside diameter of galvanized iron pipe, in inches

SIZE	PIPE A	PIPE B	PIPE C	PIPE D	AVERAGE
½	0.649	0.642	0.633	0.622	0.636
¾	0.845	0.839	0.834	0.830	0.837
1	1.062	1.064	1.050	1.053	1.057
1½	1.612	1.600	1.618	1.605	1.609
2	2.080	2.075	2.071	2.090	2.079

The ½-inch pipe shows the greatest difference. If the same difference had prevailed in the pipe upon which the loss of head tests were made and the actual diameters had been used in the computa-

tions, the effect would have been to reduce the values of c somewhat. In the case of the $\frac{1}{2}$-inch this would have meant a reduction of 4 per cent. However, as it is usually quite difficult to measure the diameters accurately, values of c computed on the basis of the standard diameters would be of the greater value.

Figures 1 and 2 show the curves that were obtained for the various sizes of lead and galvanized iron pipe, respectively. They have been plotted to a logarithmic scale in order that they may appear as straight lines, and be therefore more easily comparable with one another. The points that have been indicated are the values for the different sections from 2 to 4 feet long, and indicate the variations in the different parts of the same length. For the lead pipe, curves have been added in which c has a value of 120 and 160; and similarly for the galvanized pipe, curves in which c has a value of 80 and 120.

TABLE 3

Values of c, coefficient of discharge, of corporation cocks

SIZE	TAIL PIECE, ANGLE	VELOCITY IN FEET PER SECOND	
		10	30
inches	*degrees*		
$\frac{1}{2}$	45	0.433	0.467
$\frac{5}{8}$	45	0.496	0.500
	90	0.367	0.388
$\frac{3}{4}$	45	0.433	0.443
	90	0.380	0.408
1	45	0.445	0.445
	90	0.478	0.478
$1\frac{1}{2}$	45	0.577	0.590
	90	0.567	0.548
$1\frac{1}{2}$*	45	0.351	0.298
	90	0.300	0.322
2	45	0.459	0.467
	90	0.433	0.431
2*	45	0.306	0.326
	90	0.292	0.308

* Strainer.

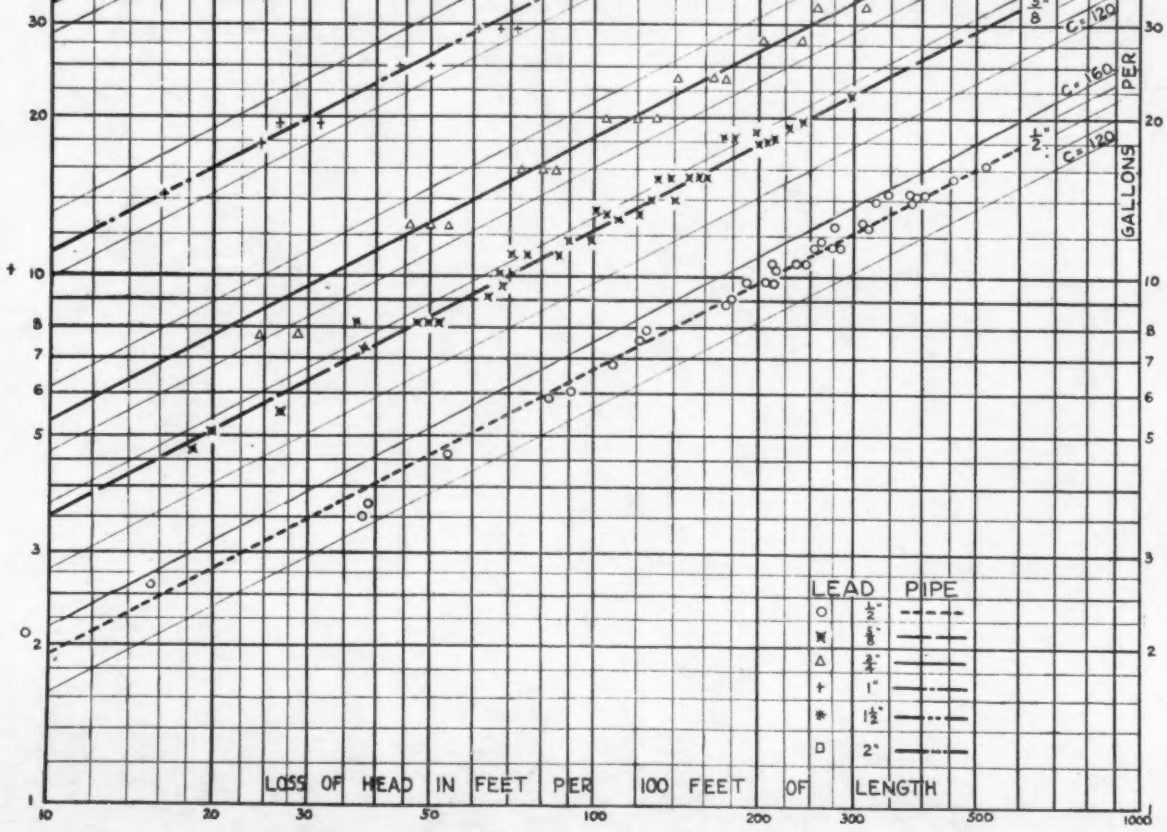

GALLONS PER MINUTE
LOSS OF HEAD IN FEET PER 100 FEET OF LENGTH
LEAD PIPE
½"
⅜"
¾"
1"
1½"
2"
C=120
C=140
C=120
10
20
30
50
100
200
300
500
1000
1
2
3
5
6
7
8
10
20
30

FIG. 1

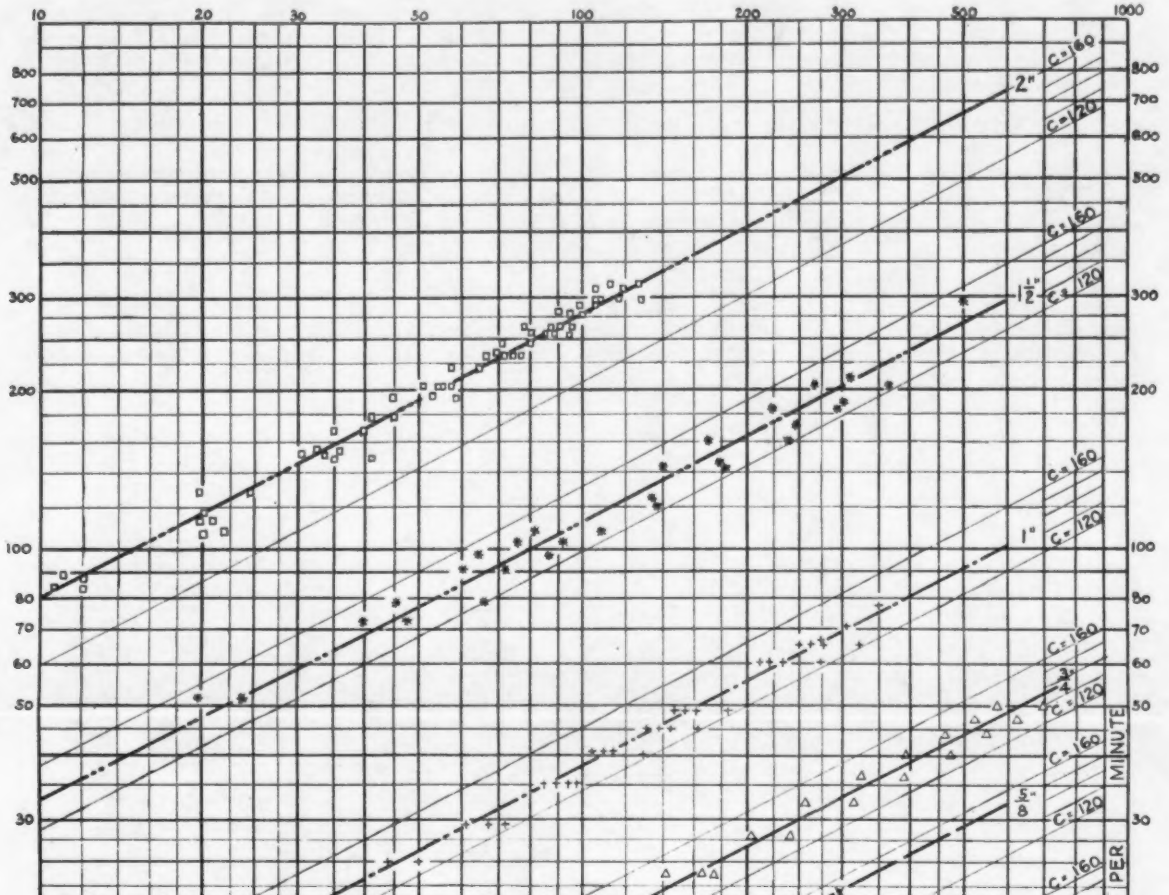

10
20
30
50
100
200
300
500
1000
800
700
600
500
300
200
100
80
70
60
50
30
2"
1½"
1"
¾
⅝
C=160
C=120
GALLONS PER MINUTE

FIG. 1

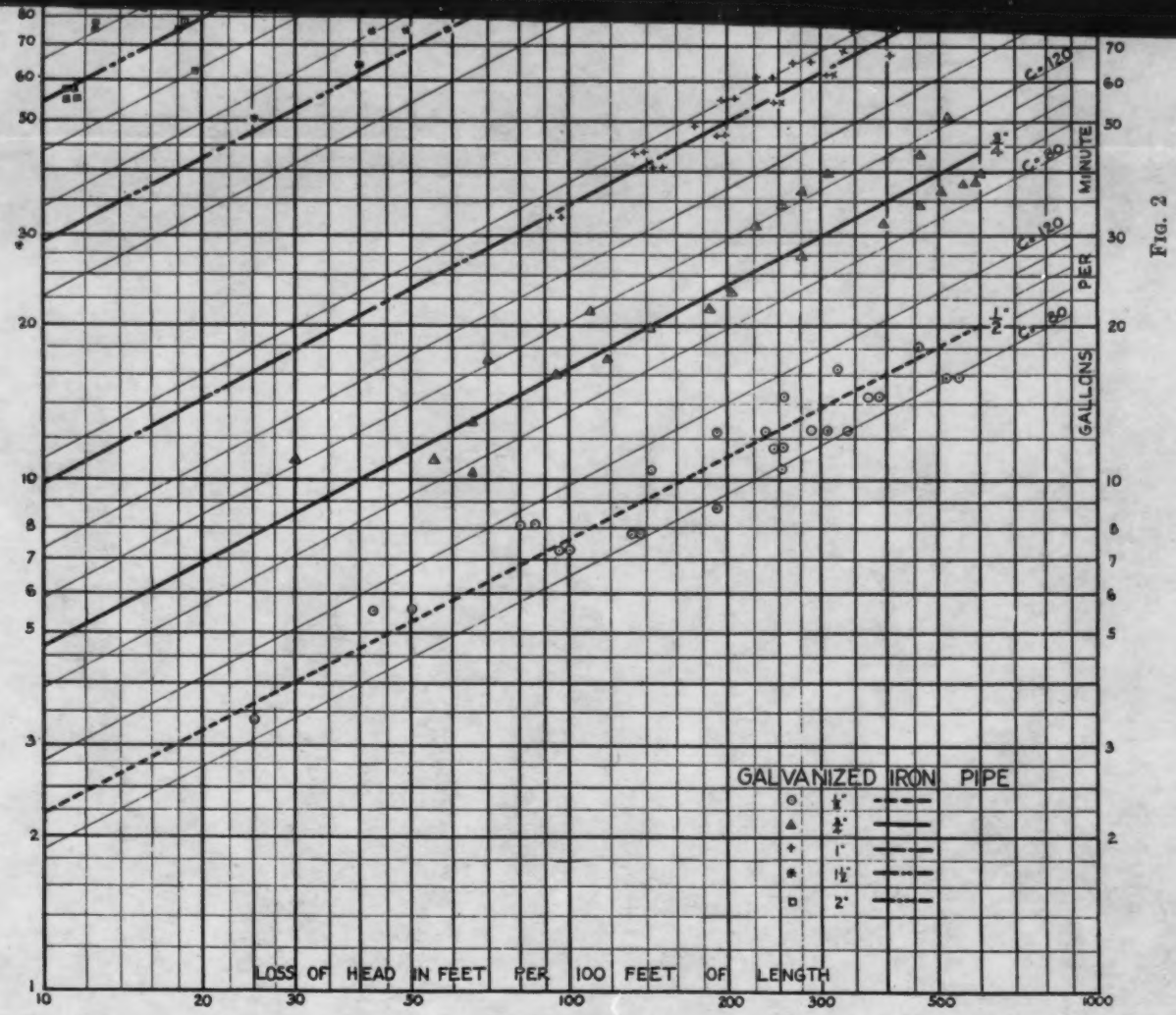

GALVANIZED IRON PIPE
¼"
⅜"
½"
¾"
1"
1½"
2"
C=120
C=80
LOSS OF HEAD IN FEET PER 100 FEET OF LENGTH
GALLONS PER MINUTE
80
70
60
50
40
30
20
10
8
7
6
5
4
3
2
1
10
20
30
50
100
200
300
500
1000

FIG. 2

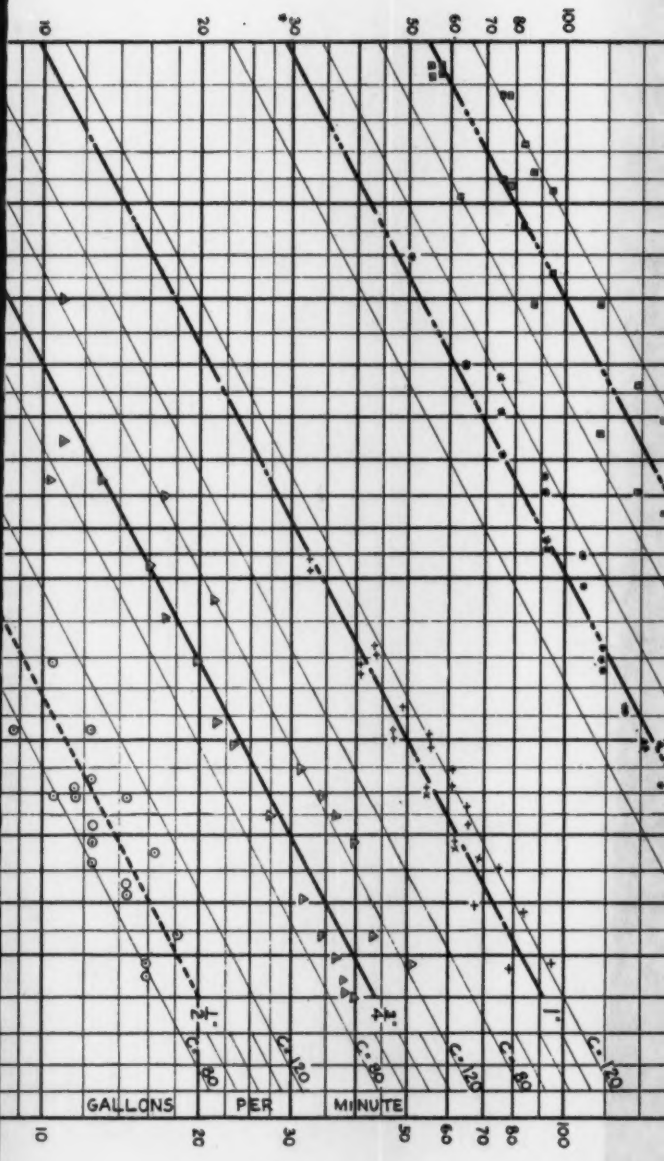


FIG. 2

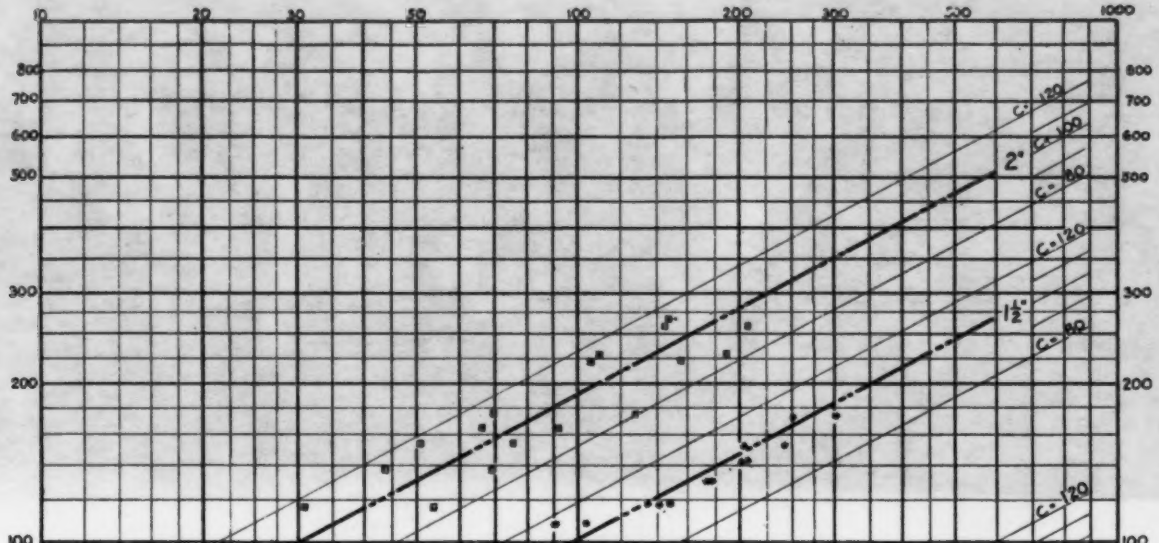

10
20
30
50
100
200
300
500
1000
800
700
600
500
300
200
100
C=120
C=100
C=80
2"
1½"
C=120
C=80
C=120

Figure 3 shows some typical sections and table 7 the principal dimensions of the various sizes and styles of corporation cocks that were tested. Cocks with strainers or eel guards are no longer used by the department. They clogged up more quickly, and were more difficult to blow out than the cocks without the guards.

TABLE 4

Lengths of lead service pipe having same resistance to flow as corporation cocks

SIZE	TAIL PIECE, ANGLE	RANGE OF DISCHARGE	CORRESPONDING RANGE OF EQUIVALENT LENGTH OF LEAD PIPE
inches	*degrees*	*gallons per minute*	*feet*
½	45	3.5– 22.5	3.86– 4.70
¾	45	6.0– 35.0	4.96– 5.94
	90	5.0– 35.0	6.24– 7.54
¾	45	8.0– 50.0	5.67– 7.17
	90	7.0– 50.0	6.65– 7.72
1	45	14.0–100.0	7.47– 9.91
	90	16.0–100.0	7.00– 9.23
1¼	45	70.0–250.0	10.00–12.38
	90	70.0–250.0	10.22–13.52
1¼*	45	30.0–160.0	14.10–23.45
	90	25.0–180.0	18.20–21.45
2	45	60.0–400.0	22.60–28.50
	90	60.0–400.0	22.95–31.10
2*	45	80.0–350.0	34.00–40.00
	90	80.0–300.0	36.00–40.75

* Strainer.

Figure 4 shows the curves obtained for the corporation cocks. They have also been plotted to a logarithmic scale. The losses shown include the velocity head, entrance head, and the frictional loss in the cock. The velocity head curves for the different sizes have also been plotted.

It will be noted that with one exception, the losses through the cocks with 90 degree tail pieces are larger than those with 45 degree tail pieces, the difference being greater for the smaller sizes. The addition of a strainer or eel guard practically doubles the loss.

The relation between the loss in the corporation cock and the velocity head may be expressed by the formula $C = H/P$, in which

TABLE 5

Pressure in street mains in pounds per square inch required to give the tabulated discharge through a corporation cock and 30 feet of lead service pipe

FLOW	DIAMETER OF LEAD PIPE, WITH SERVICE COCK SIZES BELOW																	
	2 inch							1½ inch					1 inch			¾ inch		½ inch
	2 inch	2 inch*	1½ inch	1½ inch*	1 inch	¾ inch	½ inch	1½ inch	1½ inch*	1 inch	¾ inch	½ inch	1 inch	¾ inch	½ inch	¾ inch	½ inch	½ inch
gallons per minute		*		*					*									
5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	2	3
10	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5	6	10
15	..	..	..	..	..	..	..	..	..	..	..	..	3	4	5	11	12	23
20	..	..	..	..	..	..	5	..	..	..	..	5	5	6	9	18	21	38
25	..	..	..	..	..	3	7	..	..	..	4	8	8	10	14	28	32	54
30	..	..	..	..	..	5	11	..	..	2	5	12	11	14	20	39	46	
40	..	..	..	..	3	8	19	2	3	4	10	21	18	24	35	69	80	
50	..	..	..	..	4	13	30	4	5	7	15	32	28	37	54			
60	..	..	..	3	6	18	43	5	7	9	22	47	39	51	76			
70	..	..	..	4	8	25	63	7	9	13	30	68	52	69				
80	..	..	..	5	10	33	..	9	11	17	40		68					
90	..	3	3	6	13	42	..	12	14	21	52							
100	3	4	4	7	16	51	..	14	17	26								
125	5	6	7	12	25	77	..	22	27	40								
150	8	9	10	17	36	..	..	30	38	57								
175	10	12	13	23	49	..	..	41	51	77								
200	13	16	17	29	62	..	..	52	65									
225	17	20	21	37	..	..	..	65										
250	20	24	25	45														
275	24	29	30	55														
300	29	35	36	64														

* With strainer.

H is the velocity head, and P the total loss as measured by the U-tube minus the loss through the 1 foot of lead pipe. The value of C is not a constant, being in general higher for the larger values of H. The loss P also represents the pressure required to produce the velocity head H, hence C is equal to the coefficient of discharge. Table 3 gives the values of C as computed from the curves on figure 4.

The relation between the losses in the corporation cocks and the losses in pipe can be shown by computing the length of lead pipe of a size corresponding to the size of the cock, in which the loss would be the same. This equivalent length is not a constant, being greater for the higher rates of flow and for the larger cocks. Table 4 gives the range in the values of this length for the various sizes and rates of flow indicated.

The values at other rates than those indicated may be obtained by direct proportion without material error.

TABLE 6

Loss of head in pounds per square inch in 10 feet of lead pipe; velocity head not included

GALLONS PER MINUTE	¾ inch	¾ inch	1 inch	1½ inch	2 inch
5	1				
10	2	2			
15	6	3			
20	10	5	1		
25	14	8	2		
30	.....	11	3		
40	.....	18	5		
50	.....	.....	7		
60	.....	.....	10	1	
70	.....	.....	13	2	
80	.....	.....	17	2	
90	.....	.....	.....	3	
100	.....	.....	.....	3	
125	.....	.....	.....	5	
150	.....	.....	.....	7	1
175	.....	.....	.....	10	2
200	.....	.....	.....	12	2
225	.....	.....	.....	15	3
250	.....	.....	.....	.....	3
275	.....	.....	.....	.....	4
300	.....	.....	.....	.....	5

Tables 5 and 6 were prepared from the results of these tests and have been found to be quite useful. Table 5 gives the pressures required on the street main in pounds per square inch to discharge through the various combinations of corporation cocks and service pipes, the rates of flow indicated. The figures are also equivalent to the difference in pressure between the street main and the end of the service pipe when discharging into the house plumbing under

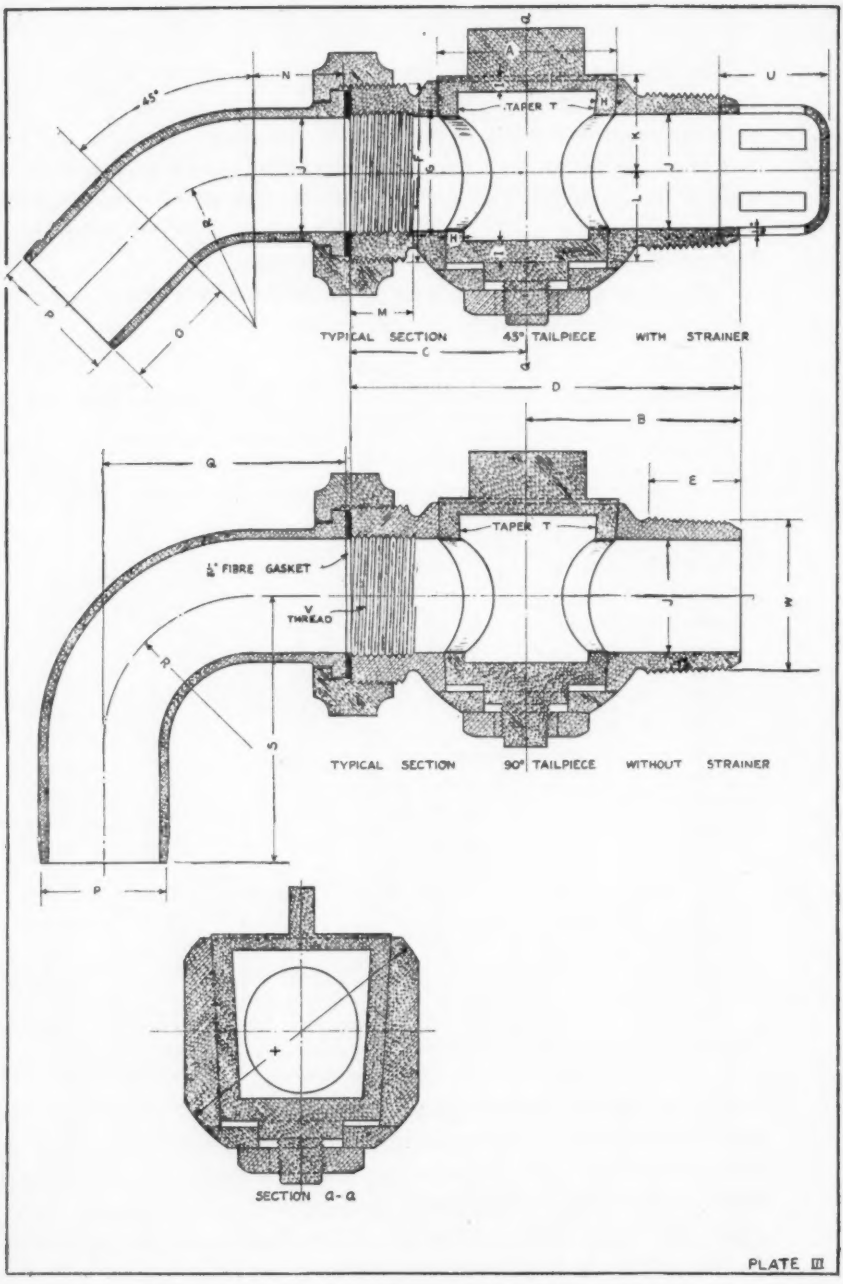


FIG. 3. SECTIONS OF CORPORATION COCKS TESTED

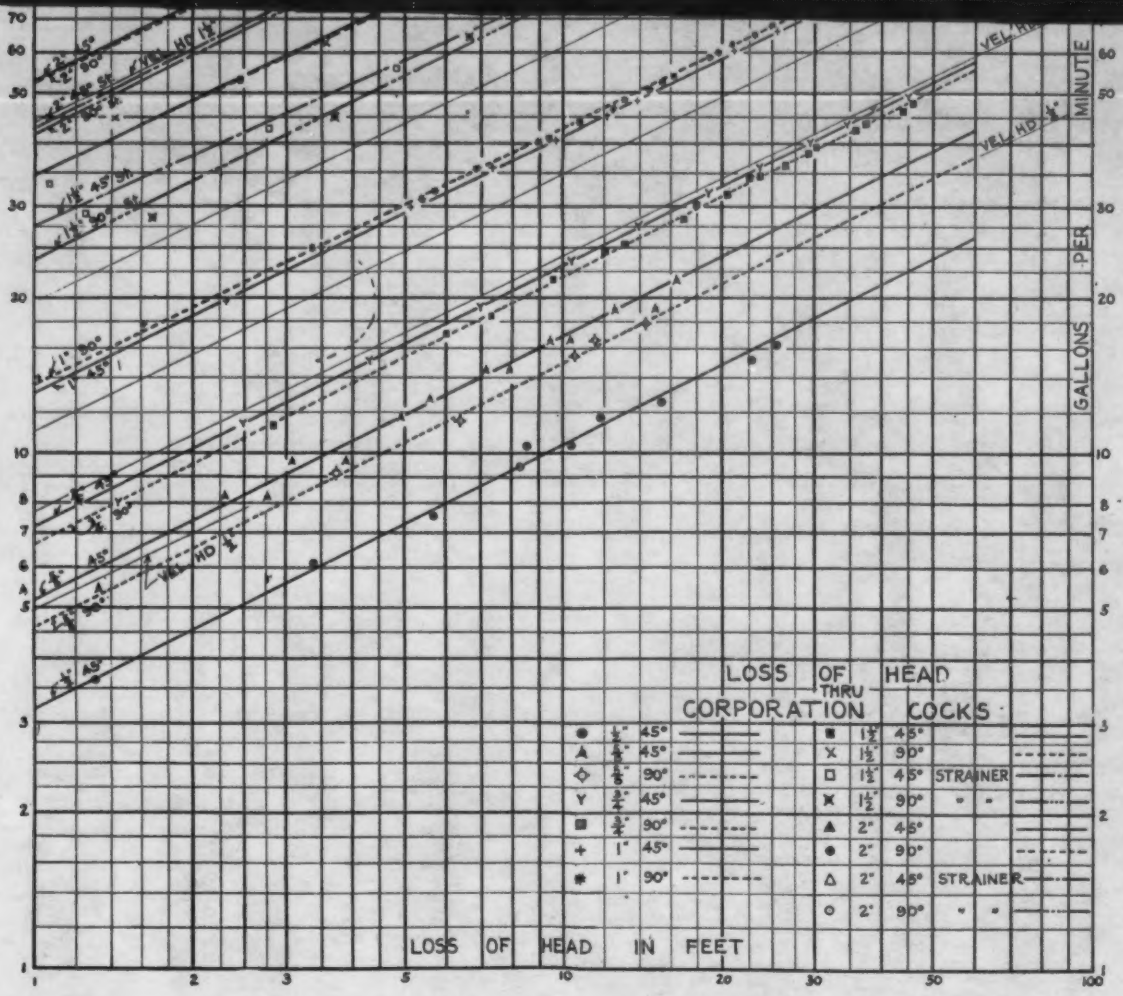

GALLONS PER MINUTE
LOSS OF HEAD IN FEET
LOSS OF HEAD THRU CORPORATION COCKS
VEL. HD.
STRAINER

FIG. 4

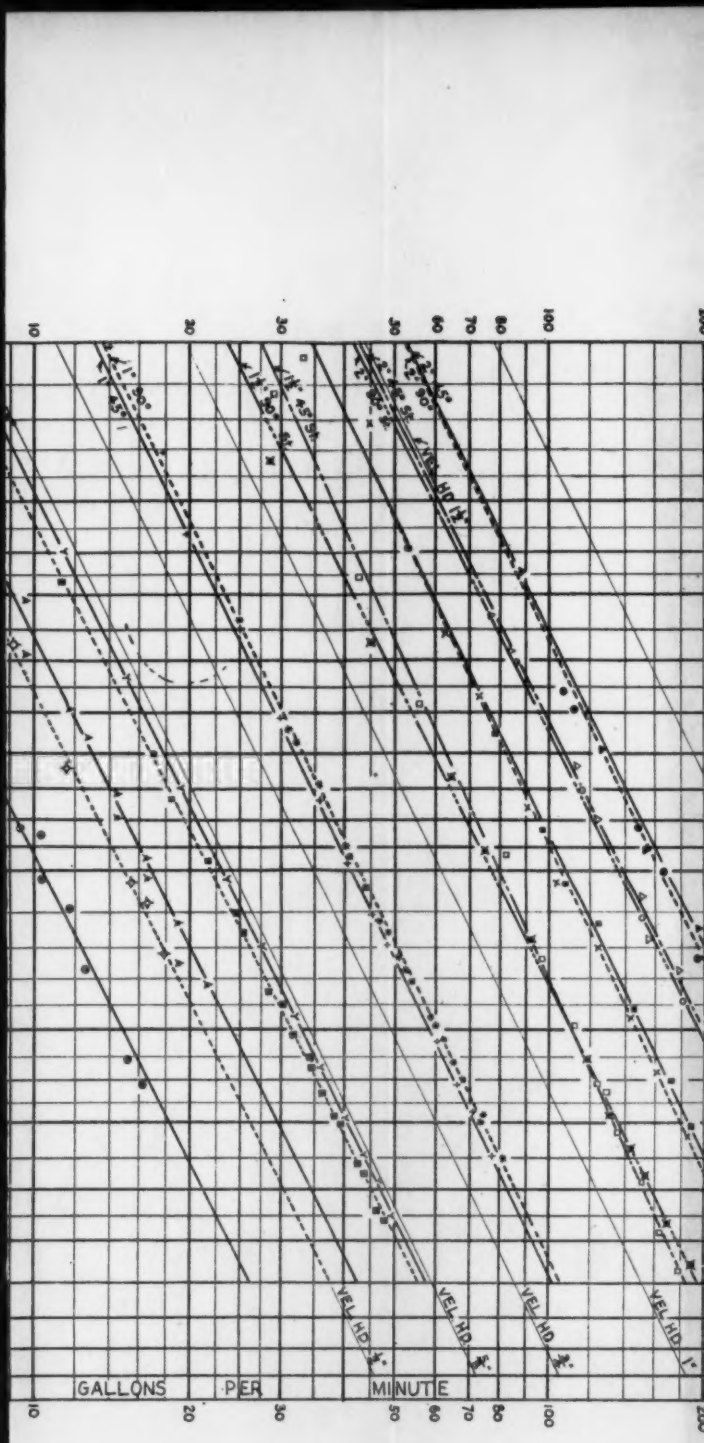
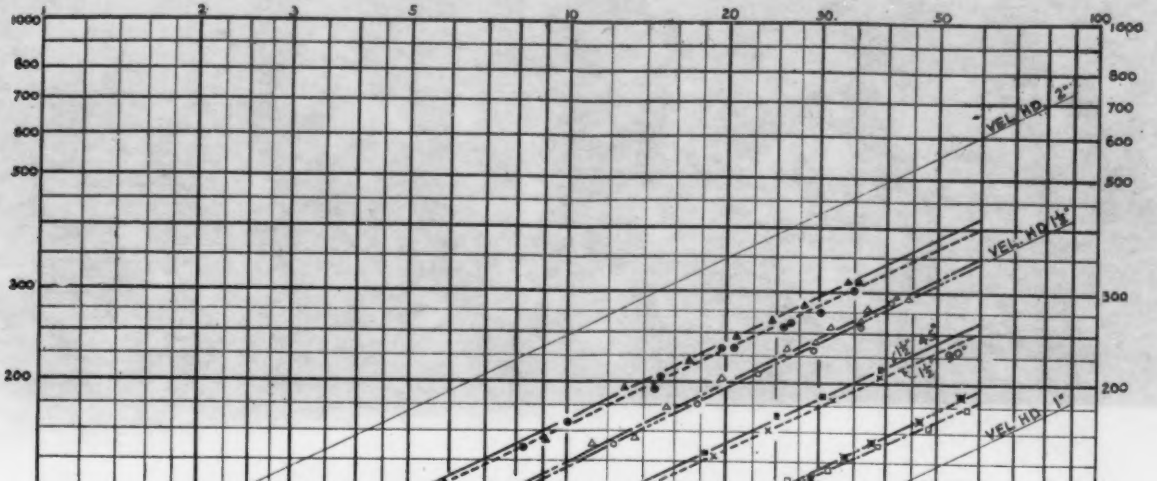

10
20
30
50
60
70
80
100
VEL HD 1'
VEL HD 2'
VEL HD 3'
VEL HD 4'
VEL HD 5'
GALLONS PER MINUTE

FIG. 4


2
3
5
10
20
30
50
100
1000
800
700
600
500
300
200
VEL. HD. 2"
VEL. HD. 1½"
VEL. HD. 1"
AIR AT 70° F. 29.92" BAR.

pressure. The length of the service pipe has been taken as 30 feet. Table 6 gives the loss through 10 feet of lead pipe. From these two tables the pressure required for any length of lead service can be readily computed.

TABLE 7

Dimensions of various sizes of corporation cocks illustrated in figure 3

	½ INCH	¾ INCH	¾ INCH	1 INCH	1½ INCH	2 INCH
A	$\frac{15}{16}$	$1\frac{1}{8}$	$1\frac{21}{64}$	$1\frac{5}{8}$	$2\frac{29}{64}$	$3\frac{3}{4}$
B	$1\frac{7}{8}$	$1\frac{7}{8}$	2	$2\frac{3}{32}$	$2\frac{7}{8}$	$3\frac{13}{16}$
C	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{21}{32}$	$2\frac{7}{16}$	$3\frac{1}{4}$
D	$3\frac{3}{8}$	$3\frac{3}{8}$	$3\frac{1}{2}$	$3\frac{3}{4}$	$5\frac{5}{16}$	$7\frac{1}{16}$
E	1	1	1	$\frac{15}{16}$	$1\frac{1}{4}$	$1\frac{9}{16}$
F	0.944	$1\frac{9}{32}$	$1\frac{9}{32}$	1.605	2.351	2.853
G	0.632	0.753	0.878	1.112	$1\frac{11}{16}$	$2\frac{3}{16}$
H	$\frac{5}{32}$	$\frac{3}{16}$	$\frac{3}{16}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$
I	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{5}{16}$
J	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	1	$1\frac{1}{2}$	2
K	$\frac{23}{32}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{15}{16}$	$1\frac{5}{16}$	$1\frac{3}{4}$
L	$\frac{17}{32}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{13}{16}$	$1\frac{3}{16}$	$1\frac{9}{16}$
M	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{11}{16}$	$\frac{11}{16}$	$\frac{11}{16}$	$1\frac{3}{8}$
N	$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{1}{4}$
O	$1\frac{1}{2}$	$1\frac{1}{2}$	$2\frac{9}{16}$	$2\frac{1}{16}$	$1\frac{1}{2}$	$1\frac{3}{4}$
P	$\frac{21}{32}$	$\frac{13}{16}$	$\frac{15}{16}$	$1\frac{3}{16}$	$1\frac{3}{4}$	$2\frac{1}{4}$
Q	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{3}{4}$	$3\frac{1}{4}$	$3\frac{1}{4}$
R	$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{1}{2}$	2	2
S	$2\frac{3}{4}$	$2\frac{3}{4}$	$2\frac{3}{4}$	3	$3\frac{1}{2}$	$3\frac{3}{4}$
U					$1\frac{3}{16}$	$1\frac{1}{4}$
V	12	12	12	12	8	8
W	0.822	1.053	1.145	1.361	2.024	$2\frac{9}{16}$
X	$1\frac{5}{8}$	$1\frac{7}{8}$	$2\frac{1}{4}$	$2\frac{1}{2}$	$3\frac{11}{16}$	$4\frac{7}{8}$
T (TAPER)	$1\frac{1}{4}$″–1′0″	$1\frac{1}{4}$″–1′0″	$1\frac{1}{4}$″–1′0″	$1\frac{1}{4}$″–1′0″	1″–1′0″	1″–1′0″
Strainer	Number of openings				6	10
	Size of openings				$\frac{7}{8}$″ x $\frac{5}{16}$″	$1\frac{1}{8}$ x $\frac{5}{16}$″

PRESIDENT'S ADDRESS[1]

By Major Theodore A. Leisen

Conditions during the past year have been abnormal and as a natural sequence, the affairs of the Association to a certain extent have been affected thereby. For this reason, it is not possible to expatiate upon any extraordinary achievements or record-breaking accomplishments as a result of the year's progress. That we have held our own so well financially and in membership is ample reason for congratulation and is testimony of a healthy, stable existence.

If a brief reference may be permitted to the internal dissensions which characterized the last annual meeting, it can be stated that the storm clouds which then hovered over the Association's affairs—fraught for a time with a menace of serious disaster—appear to have cleared away, and the hope is sincerely expressed that now and in future, all personal feelings will be suppressed in the interests of that spirit of universal coöperation and service without which this Association cannot expect to attain and maintain the purposes for which it was formed, and which all members who have the interests of the Association at heart so earnestly desire.

The revision of the Constitution is one of the most important matters which is now before the Association, and some of the amendments as finally concurred in by the Committees, it is believed, will have a tendency to insure smoother operation in the affairs of the Association, and eliminate or reduce undue friction, if the amendments are adopted. The amendments involved have received very careful consideration by both the Committee on Revision of the Constitution and by the Executive Committee, and the results were placed before the membership in ample time to permit a thorough understanding of the questions at issue before the matter is brought to a vote.

At no time in the history of the country has the necessity for the beneficial influence of national associations been more vital to their membership than during the existing crisis and this is particularly

[1] Read at the St. Louis Convention, May 15, 1918.

so in connection with those representing public utilities in general and public water supplies in particular.

One of the principal lines of service which this Association should endeavor to render at this time to that large portion of its membership who represent directly or indirectly the management of water works, is coöperative assistance through proper channels in obtaining fuel and other commodities essential to the continuous and efficient operation of the plants. The first move in this direction was the affiliation with the National Committee on Gas and Electric Service, and was productive of considerable good, but there was an apparent lack of effort to take full advantage of this committee's facilities and services, or much better results might be recorded. Other steps tending to effect these results are now under contemplation and it is hoped that the combined efforts along these lines will afford marked relief in obtaining prompt deliveries of coal and other supplies to all water works administrations.

Despite certain handicaps which hampered some of the work during the past year, the activities of the Association as depicted by the official Journal have not fallen below the average standard of other years, but a still higher standard is attainable and it sh uld be the earnest effort of every individual member to strive unremittingly for that goal.

There are many other questions to which it would be possible to refer, but the crowded condition of the program offers an excellent excuse for condensing this address, and the over-burdened status of my position at this particular time affords an even better one for not inflicting on the members a prolonged statement or discussion of matters with which they are already familiar.

In conclusion, I desire to express my sincere gratitude to the Association for the confidence shown and for the honor conferred in electing me to the Presidency, and to offer my apologies for not having given to the affairs of the Association the full measure of attention which the position of president demands. For the major portion of the year, it has been a question of service to the Association or service to the Government, and what I was able to give was devoted to the latter, to the detriment of the Association's affairs. The committees have mostly performed excellent service, and their good work was in marked contrast to the delinquency of your President.

HISTORY OF THE ARTESIAN WATER SUPPLY AT SAVANNAH, GEORGIA[1]

By E. R. Conant

Savannah, the county seat of Chatham County, Ga., has a population of 80,000. The county is in the eastern section of the coastal plane, and has an area of 370 square miles. Savannah is 18 miles from the sea coast and is on the south bank of the Savannah River, and the elevation of the city above sea level ranges from 14 to 40 feet.

Historical. Previous to 1854, when the city had a population of 15,000, the domestic supply was obtained from wells ranging in depth from 15 to 30 feet. They were of the ordinary circular type lined with stone or brick, and ordinary hand pitcher pumps were placed at the top of them. The city maintained these wells and pumps, and the records show that the annual expenditures for obtaining a ground water supply by maintaining some 150 wells, ranged from $3000 to $7000. The records state that the water furnished was soft and wholesome, but in one of the old city reports, it was stated that mulberry trees growing anywhere near these wells were required to be removed, because they affected the purity of the water, in what way the author cannot imagine.

The city also constructed and maintained approximately twenty large brick cisterns under ground, each with a capacity of from 5000 to 10,000 gallons, which were kept filled for fire service only. These were abandoned many years ago, but the author in paving a street recently discovered one of these old cisterns and after opening it at the top found it to be partially filled with clear water, and there was no algae growth on the walls. The cistern was entirely closed, the water entering it by percolation through the brick. Unfortunately no bacteriological analysis was made of the water to ascertain whether it was potable.

In 1851, the mayor and aldermen engaged the services of A. W. Craven, chief engineer of the Croton water works, New York, as consulting engineer to design a project for obtaining a surface water

[1] Read at the St. Louis Convention, May 14, 1918.

supply from the Savannah River. This supply was put in operation in 1854, and the author found in one of the old reports that the first Worthington type of pumping engine was installed at Savannah under this project. Water partially filtered was taken from the Savannah River at a point opposite the thickly populated portion of the city, and pumped to a standpipe, from which it was distributed by mains over a portion of the city. After twenty years operation of this plant, it was believed that the health conditions of the city would be improved if the intake at the river was further from the city proper, and a new pumping station, locally known as the river station, was constructed at a point $1\frac{3}{4}$ miles up the river, and this station was used for pumping direct from the river until 1887, when an artesian well supply was adopted.

Introduction of artesian wells. In 1879 the mayor of the city brought up the question of the possibility of obtaining a water supply by boring artesian wells. Little was known of artesian wells at this date and for a number of years the city authorities were skeptical of obtaining a suitable supply by this method. As far as the author can learn the earliest artesian or deep well in Georgia was bored in Savannah in 1882, and the boring of others soon followed, as they were self-flowing and furnished a most desirable quantity of water. The agitation for obtaining an artesian well supply for Savannah resulted in the boring of several wells, and at the end of 1887, 15 wells had been bored near the river pumping station alluded to above, and a small reservoir was constructed into which the water from the wells entered by gravity, and the city's supply was obtained from these self-flowing wells. With a diminution of the flow, due to the lowering of the static head, the wells failed to furnish the necessary supply, and to make up the deficiency a portion of the supply was taken from the Savannah River and temporarily mixed artesian and river water was used.

Geological data. The Atlantic coastal plane reaches from New York to the Florida straits. This plane is underlaid by a great sediment of superficial deposits consisting of gravel, sand, clay, marl and loam, and in certain localities lime rock full of cavities exists, which forms the aquifer into which the water pours from the catchment areas through a stratum of sand beds, which have a general seaward dip. These aquifers form valuable underground water resources. Along the coast of Georgia there is a strip 25 to 40 miles wide bordering the coast overlying water-bearing strata or aquifers through which water

comes from a catchment area located from 80 to 100 miles northwest of this coast line. The character of the water obtained from the aquifer along the Georgia Coast is in almost every instance potable and suitable for a domestic supply, and at this time there are over 1000 wells tapping the aquifer in this state alone. The direction of the flow from the catchment area to the aquifer at this locality is in a southeastern direction, and it is observed that the interference of one well over another is less when they are bored on an axis perpendicular to the line of flow than where they are promiscuously bored, as was the case with the first artesian well supply at the river pumping station, above referred to.

The strata penetrated in boring artesian wells at Savannah consist of 250 to 300 feet of clay with interbedded layers of marl and sands, and under this from 220 to 250 feet of porous limestone, or more strictly speaking, limestone with voids or cavities. The principal water-bearing stratum is in the limestone. Below this, for 300 to 350 feet, a formation of marl intermixed with some shell is found until a shallow stratum of flint rock is struck at about 950 feet below the surface. Below this, for a depth of 50 feet, is another water-bearing stratum of limestone similar to the upper aquifer.

Gwinnett Street pumping station. As noted above the supply at the river station was insufficient to meet the needs of the city, and in 1891 a new project was adopted for supplying it with artesian water, which project at the time was one of the most carefully planned of any in the country. The site selected for the new pumping station is two miles southeast of the river station, well within the corporate limits of the city. The city employed as consulting engineer, Thomas F. Johnson, of Chicago, who at the same time was installing an artesian supply at Memphis, Tenn. The plan here consisted of boring 12 wells 300 feet apart in a continuous line nearly perpendicular to the line of the subterranean flow. The depth of the wells is from 500 to 600 feet. They are all 12 inches inside diameter, and the casing is driven to a depth of approximately 250 feet, where it is imbedded in rock so that there can be no contamination of the aquifer from surface water following the casing. A brick conduit 6 feet in diameter was constructed from 10 to 16 feet below the surface of the ground on a level grade, with elevation at mean low water, into which the wells flow, and the water is carried through this conduit to the pump well at the station.

The pumping equipment consisted of two Holly engines of the Gaskill type of 10,000,000 gallon capacity each. A 42-inch main was laid from the pumping station to the edge of the thickly populated section of the city, 4000 feet distance. This station is ¾ mile from the center of the water supply distribution. No standpipe or reservoir was provided, and at this date there is no standpipe or reservoir other than a small pump well which has a capacity of 40,000 gallons, and the brick conduit, which has a capacity of approximately 600,000 gallons. This pumping station was put in operation in 1893, and has been in continuous use without interruption since then.

When the Gwinnett Street station was put into operation the river station was shut down, and was not utilized, except for emergency use, for 11 years, and since then this station has only been used to make up any deficiency in supply that the Gwinnett Street station could not furnish with one pumping unit, the supply from the river station being about 10 per cent of the total consumption. The wells at the Gwinnett Street station were at first self-flowing, but the flow gradually lessened and an air lift plant was installed in 1902, consisting of two Ingersoll-Rand air compressors of 1800 cubic feet capacity of air per minute. In 1908 a single air compressor of 1200 cubic feet per minute capacity was installed at the river station. The method of operation at the Gwinnett Street station, is to work one unit for a month, then shut down this unit and operate the other, except in case of fire, when an increased supply is required, then both engines and compressors are immediately put in operation. The river station is only operated during the day, except when a peak load has to be provided for.

Static head of wells. When artesian wells were first bored in and near Savannah, the water rose to from 30 to 35 feet above mean low water. With a continuous draft upon the aquifer, the static head fell, and the rate and amount of lowering of the static head depends largely upon how concentrated the draft on the aquifer is at any locality. Take, for instance, the river station where 25 wells were bored promiscuously within a 10-acre tract. Records do not give the fall in the static head at the river station after the wells were first bored, but the diminution of the flow that occurred would indicate that within three years after they were put in operation the static head dropped at least 20 to 25 feet. Artesian wells were bored at the river station in 1887–1889, and between that year and 1893, the domestic supply, with the exception of a small percentage of pumpage

at times from the river, came from these wells. With the construction and operation of the Gwinnett Street station in 1893, the river station was shut down, excepting for very brief periods, until 1909. Since 1909 both stations have been in operation, but only from 1,000,000 to 4,000,000 gallons daily has been drawn from the wells at the river station; therefore, there has only been a light draft on the aquifer at this locality, and the elevation of the static head has changed but little.

At this time the elevation of the static head at the river station is from 4 to 6 feet above mean low water, whereas at the Gwinnett Street station, only 3900 feet away, where there is heavy continuous draft upon the wells, the static head of the 12 wells adjacent to it averages 12 to 14 feet below mean low water. Sufficient data have been collected to show approximately the rate of lowering of the static head at this station from 1893 to the present time, and if the fall in the static head was graphically shown, the line showing the lowering of the static head would form a parabolic curve with the flattening out of the curve occurring at this time.

In 1890, when the wells were first bored at the Gwinnett Street station, the static head there was approximately 28 feet above mean low water, and the static head of the original wells bored in this vicinity was approximately 35 feet above mean low water so that the operation of the wells at the river station previously to the boring of the wells at the Gwinnett Street station evidently effected to some extent the water pressure in the aquifer at the Gwinnett Street station. Three years after the wells were first put in operation at the Gwinnett Street station, the static head fell 12 feet, and five years later the static head had fallen 5 feet further. Unfortunately there is no record of the elevation of the static head in 1902, when the air compressors were first installed, and not until 1915 was the static head carefully determined by the author, when it was found to be from 10 to 12 feet below mean low water. In other words, during the last 17 years, the static head at the Gwinnett Street station has dropped approximately 22 feet, equivalent to an annual drop of somewhat less than 1½ feet.

Assuming that a still further flattening of the curve of the static head lowering occurs, it will be a long time before the drop will fall to such an extent that the cost of obtaining water either with electrically driven pumps or with an air lift system will be excessive. With the present air lift system the additional cost per million gallons

pumped per each foot of sinking of the static head is 15 cents. Undoubtedly a continuous heavy draft on the aquifer will cause a continued lowering of the static head, but if there should be an interruption in pumping for any length of time the static head would return to an elevation considerably above mean low water. Wells just bored on the prolonged axis of the existing wells and distant 900 and 1600 feet from the nearest old wells have the elevation of the static head at approximately low water. New wells that have been bored within a distance of 2 or 3 miles of the river station are self-flowing at this date.

In connection with the static head it is necessary to consider the draw-down, which is proportional to the draft placed upon the wells. The draw-down at the Gwinnett Street station wells is from 12 to 15 feet, and at the river station approximately 6 feet, but if the air is cut off, the water rises rapidly to its ordinary static head elevation.

Interference of wells. As stated above, the wells at the river station were bored promiscuously in a small area, without any relation to the line of flow of the aquifer, and the wells interfere one with the other much more than at the Gwinnett Street station. Nine months ago a new well was bored within 90 feet of the one of the old wells at the Gwinnett Street station, and there has been very little interference between the two.

The static head has apparently only dropped 2 feet at this point, due to the additional draft on the aquifer. That this well has not interfered more with the old wells near it, can only be explained by the fact that the new well is a little deeper and evidently enters pockets that the old well does not draw from. We have one deep well 1500 feet deep, within 1000 feet of one of the old wells, which taps two aquifers. The static head is higher and the draw-down in this well is very much less than in the other wells.

Capacity of wells. While the aquifer has been tapped for a period of twenty-nine years, there is just as much water in the aquifer at this time as there was originally, as shown by the capacity of the wells, but it is necessary to go a little lower for the supply. When the wells were first bored at the river station the capacity of the 22 wells was approximately 6,000,000 gallons and it is easy to obtain this quantity now. Reference to the capacity of the wells at the Gwinnett Street station for various periods gives better data as regards the strength of the aquifer. When the 12 wells at the Gwinnett Street station were

bored in 1892, the total flow from it was 10,300,000 gallons per day. In a year or two this flow diminished to 9,500,000 gallons and in 1897 the records show the flow to be further reduced to 5,500,000 gallons. In 1900 the flow was slightly less, recorded as 5,000,000 gallons, and in 1902 the flow was approximately the same, but when the air lift system was introduced in 1902, the capacity of the wells increased to 10,300,000 gallons per day. Tests made by the author of the capacity of the same wells in 1915 showed the supply to be at the daily rate of 15,000,000 gallons, and at this date the city is obtaining this quantity without any effort, in fact at this time it is pumping from 8 wells and obtaining 10,000,000 gallons per day. This shows that there is a great subterranean flow, which is believed to be inexhaustible, and all that is needed is for a suitable distribution of wells to draw water without creating a too concentrated draft on the aquifer. The air is applied to the wells through 2½-inch pipe with no nozzles or air pump at the lower end, and the submergence is around 60 per cent. Not a well has been lost since they were first bored, this being due to the wells entering a limestone formation where there are no heavy pockets of sand.

Before the installation of the air lift, attempts were made to increase the flow of the wells by dynamiting, which produced no appreciable benefit. Another method was attempted of applying water under pressure to the wells. This was done by laying an 8-inch main along the axis of the wells and connecting the well with it. This flushing did increase the flow for the time being about 12 per cent. The running pressure of air at the wells at this time ranged from 22 to 30 pounds, with 45 pounds air pressure at the station.

Chlorine contents. One feature with artesian wells that requires attention is the possibility or probability of salt water entering the aquifer as the static head is lowered. It so happens that several analyses of artesian water were made in 1893 and the chlorine content of the water at that time was found to be 6.1 parts per million. In 1915 the chlorine content was found to be 6.2 parts per million, showing that up to this date there had been no increase in the salinity of the water. The wells that go to the lower aquifer reach a water of slightly different chemical analysis, the chlorine contents being about 14 parts per million.

Analyses of water from the artesian wells at Tybee, fifteen miles distant, which is on the sea coast, show the chlorine contents to be 6½ parts per million, so that apparently there is no fear of the water

at Savannah becoming too salty for potable or domestic use for a long time to come.

Tidal interference. There is some oscillation in the static head of some of the wells, corresponding to the rise and fall of the tide at the sea coast, and this amounts in some localities to about 4 feet. It is not appreciable in the wells at the Gwinnett Street station, where water is drawn from the aquifer all the time. At the river station, when there is cessation in the pumping, the static head varies somewhat, and other wells in the county that are self-flowing have a stronger flow when the tide is high than when the tide is out.

Consumption of water. Savannah at this date has a population of approximately 80,000. The average consumption is 10,300,000 gallons per day, or a per capita consumption of 129 gallons. The consumption has fluctuated in the past from 115 to 165 gallons. This has been due in part to abnormal pumping during extraordinary cold spells and the extension of house drainage system, but especially to the large waste due to faulty plumbing.

A pitometer survey was made in Savannah in 1912 and considerable saving in pumpage was brought about by the work done following this survey. In the mains the pressure, which at one time was 30 pounds, has been increased to 50 pounds. The city has commenced the installation of meters and has passed an ordinance requiring stop and waste cocks on all risers. It is carrying out house to house inspection of all plumbing fixtures. The installation of only 700 meters last year brought about 4 per cent reduction in the per capita consumption.

Fuel consumption. Accurate records have been kept of the fuel consumption at the Gwinnett Street station since it was first put in operation in 1893. When the new pumps were first installed the consumption was 2000 pounds per million gallons pumped into the mains. Rather singularly the consumption sank regularly for a period of five years when 1450 pounds of coal pumped the same amount of water. This was during the period whem the wells were self-flowing. The lift from the pump well is approximately 12 feet and the pressure in the force main was at that time from 20 to 30 pounds. The installation of the air compressor increased the amount of fuel required to 2600 pounds of coal per million gallons pumped into the mains, but after efficiency was brought about in the operation of the air lift, the fuel required fell to 2100 pounds. From 1904 to 1914 the annual increase in consumption of coal has been 90 pounds per mil-

lion gallons pumped. This, of course, is accounted for by the slowly receding elevation of the static head, to the machinery becoming older and to the increase in pressure in the mains from 30 to 50 pounds, so that at this time the consumption is 3240 pounds of coal per million gallons.

The city's destructor plant, which destroys the city's refuse, was put into operation in March, 1914, and is operated by steam furnished by burning the refuse. The excess steam not required to operate the plant itself is conveyed from the boiler to the main boiler head at the pumping station. This excess steam for three years and nine months has resulted in the saving of $26,100 worth of coal, and if there was enough refuse to operate the destructor plant at its full capacity, the saving for this period would have been about double this amount. This total cost of operating the station, including maintenance, fuel and incidental expenses not excluding interest on investment, depreciation, or allowing for any sinking fund, has been on the average of $12. per million gallons pumped. At this time with abnormal conditions, the operating cost has risen to $16. per million gallons.

Deterioration of well casing. Investigation made of one well casing removed from the River Station showed it had suffered deterioration. On account of slight contamination of the water occurring at the river station two years ago, a thorough investigation was made to ascertain how this occurred, and this investigation has shown beyond a doubt that infiltration of surface water occurs through some of the well casings. In order to prove this, an attempt was made to withdraw one 10-inch casing and with the application of two 100-ton jacks the author succeeded in withdrawing 150 feet of the pipe, which then broke off at this depth. In the casing, at a point about 40 feet below the surface, a hole was found which it was thought at first might be due to electrolysis but was finally concluded to be due to corrosion. At present, to avoid contamination of the water, in the morning before pumping occurs into the mains, it is customary to apply the air compressor and waste the water from the wells for a period of one hour. This eliminates the accumulation of infiltered water through the previous night and with this operation there has been no trouble, as continuous pumping creates internal pressure in the casing greater than the outside pressure, thus keeping out infiltration. These casings have failed after 26 years life, and it has been planned to do away with this station within a few months.

The plan for improving the Gwinnett Street station includes the installation of electrically operated pumps of 1½ million gallons daily capacity, thoroughly overhauling the present machinery, and setting additional meters to reduce the waste, so that the one station with one unit will supply the present demands.

Cost. The construction of the river station, which was met by a bond issue, cost $220,000; other outlays, such as the cost of the air lift system, for this station have been $57,000.

The initial cost of the Gwinnett Street station was $427,000, and since its construction to the present date $80,000 was expended for air lift plant and for new wells, making total construction cost $784,000.

Financial management. With the exception of one bond issue of $200,000, to pay for the first construction in 1882, all costs of construction, maintenance, extensions and renewals have been paid from the current revenue derived from the sale of water.

The management of the water works of this city has not been unlike the management of many municipalities, in that no sinking fund has been provided and any excess revenue over the expenditures for outlays or operation has been thrown into the treasury and used for any municipal use. No charge has been made against various departments for water furnished; the city has been exceedingly liberal as regards free water and only recently has taken proper steps to prevent and avoid wastage by the consumer.

From 1882 to the end of 1917 the revenue from the water works department has been in round figures $3,359,000. The total expenditure for the operation and maintenance for this period was $1,320,500; for construction of plant and mains and installation of air lift system, boring and connecting wells, a total of $1,328,500 was expended.

The cost of construction, boring of wells and connecting them, amounted to $1,328,500. An inventory of the water works department made by the author at the end of 1917 places the value of the physical portion of this department at $826,950; therefore, the depreciation is estimated at $501,550.

The total outlay for the past 36 years was $2,649,000, giving a surplus, excluding depreciation, of $710,000, or a net surplus, allowing for depreciation, of $208,450. There are no outstanding liabilities and the plants have been fully paid for. If the plant was privately owned, interest on investment would have to be considered, but this is more than offset by the public and free service that has been given.

It can be seen that rates for water have been fixed very closely to what has been required to meet the expenditures, but there should have been a sinking fund provided. Had there been a sinking fund the much-needed rehabilitation and extension of the water works system could be carried out at this time without recourse to a bond issue, which will be required within the very near future.

The per capita income is very much less than the average per capita income of other municipalities. In Savannah it is somewhat less than $2.00 per year per capita, while the average in the United States is about $2.50 per capita.

The total pumpage for 26 years was 97,408,000,000 gallons, making the total cost per million gallons pumped, including cost of construction, maintenance, all outlays, including extension of mains, etc., $27.20.

WATER WASTE ELIMINATION. METHODS AND RESULTS AT OAK PARK, ILL.[1]

By H. P. T. Matte

All will agree, no doubt, that the most important factor in the elimination of waste is complete meterage. This belief is held firmly in Oak Park, but the author will try to show that it must be supplemented by other measures in order to be entirely effective. These have been divided into the following heads:

1. Strict maintenance of meters.
2. Rigid collection of high bills due to leakage or waste.
3. Efficient complaint department, to take care of complaints caused by excessive water bills. This includes education of consumers.
4. Master meter for measuring the entire supply to the distribution system. That is, a recording Venturi meter, or any of the various types of recording pitometers, with accompanying recording pressure gauges.
5. Periodical waste surveys.

To these may be added the following, important, although often overlooked, elements in the control of waste:

6. Absolute control of all the divisions of the water department by the manager.
7. Strict adherence to the rules and regulations, or ordinances. This means that the water department must be upheld by the municipal authorities. In other words, let the water works be out of politics entirely.

The foregoing rules have been in force in Oak Park, and to that fact the author ascribes the following results:

During the four-year period between 1913 and 1917 inclusive, although the population has increased 34.6 per cent and the number of services or meters 32.5 per cent; the daily consumption increased only 20.7 per cent. The daily per capita consumption has decreased from 75 gallons to 67.6 gallons, or 10.6 per cent, the minimum night

[1] Read before the Illinois Section at Urbana, April 18, 1918.

rate of consumption diminished 37.5 per cent and the ratio of the minimum night rate to the average daily consumption, dropped from 40.8 to 21.2 or 48 per cent. The percentage of water accounted for by meters has increased from 72 per cent to 83 per cent.

Oak Park has always been 100 per cent metered. All the water pumped into the distribution system, except that which is lost through underground leakage, is delivered through meters. This

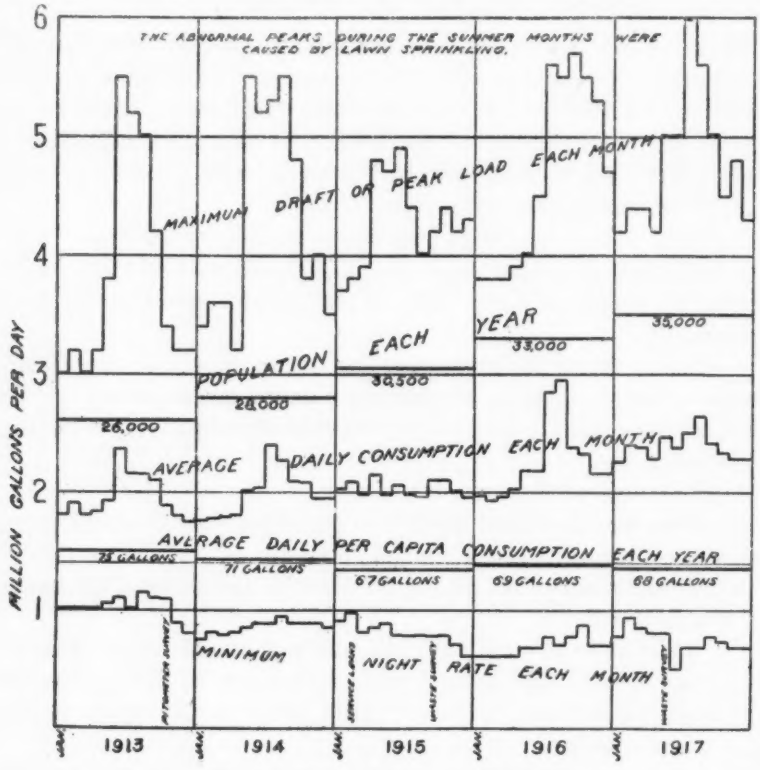


FIG. 1. WATER CONSUMPTION AT OAK PARK, ILL.

includes all municipal buildings, watering troughs, drinking fountains, street sprinkling water used in parks, and fire hydrants when used for other than fire purposes. Water used in the construction of houses is sold through meters buried in the parkway. Moreover there is no free water.

Referring to item 1, maintenance of meters, all meters are tested periodically, a practice which has been found profitable, although

not required by the Public Utilities Commission. Meters are read every quarter in a continuous reading system, for which purpose the city is divided into six districts so that those found to be not registering can be brought into the shop, repaired and put back into service within a week after being read.

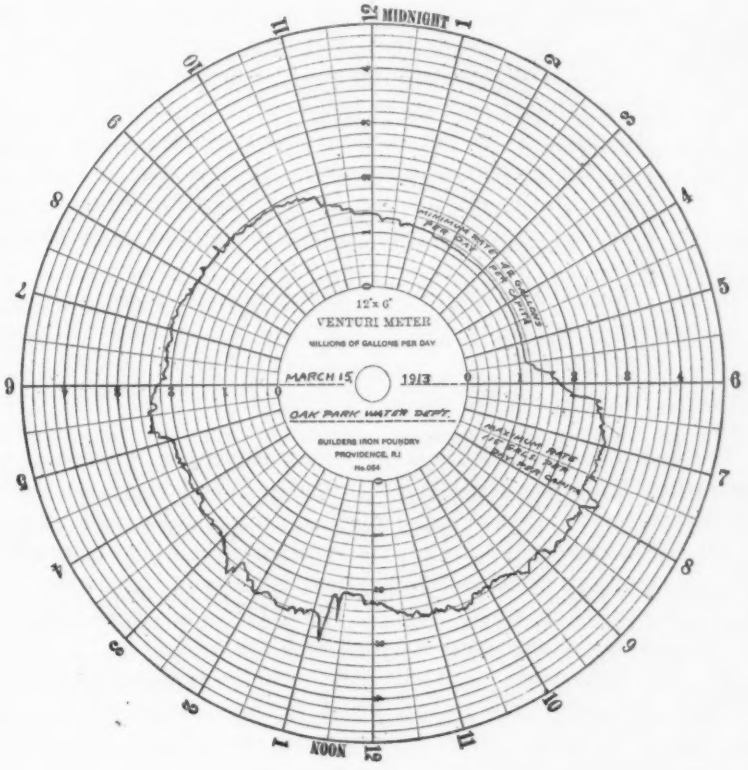


FIG. 2.

The second point, the rigid collection of high bills due to leakage, is important and has a beneficial effect on the success of the meter system: In other words, although it may be hard on the consumer, he will, if properly impressed, appreciate the importance of watching his fixtures and become educated in spite of himself.

No reduction in bills is made on account of leakage. Short and pointed instructions, which include the policy of the Water Department, are printed on the backs of the water bills. If the complain-

ant has been guilty of the characteristic failing of mankind, that of being unobserving and neglecting to read the information supplied to him every three months, he deserves to pay for his inattention.

This does not mean that the department is heartless and does not admit mistakes. The consumer is given the benefit of the doubt from the first, owing to the fact that the department realizes that it is but human and can be in error in several ways. In fact the department lets it be known that it is glad to correct its faults. If, however, upon thorough investigation it is found that the water was consumed through leakage or otherwise wasted, the bill must be paid. In order to be fair certain allowances are made if the waste was in the ground and invisible. In this case the lowest rate at which water is sold in Oak Park is allowed, although the quantity consumed may not justify the consumption to be placed in that class.

In any case of high bills, whether this concession is given or not, if the consumer is plainly unable to pay the bill as it stands (these claims being investigated), an installment plan of payment is adopted; but with the provision that the bill must be paid within a year.

The reason for this attitude is this; every student of human nature knows that if a water department is reputed to be lenient, the average person takes a chance and depends upon his ability as a bluffer to get out of paying the bill. Talk is cheaper than plumbing bills. If he is victorious because "he has been unfortunate and won't let it happen again," he surely will. In the old days of leniency it was found that the average consumer *did* do it again.

But it is impossible to handle this matter properly without an efficient complaint department, for it is then impossible for the department to prove its case. Every water works man who has had to deal with consumers under the meter system is aware of the number of excuses and prevarications that are evolved in order to make the management believe that there was a mistake made in the reading, that there are no leaks, that the fixtures have been repaired recently, that the meter works when no water passes through it, that the meter reader is in collusion with the "bunch of grafters in the office" and reads the meter from the next block, and so on.

Oak Park, however is prepared to prove to all these amateur lawyers that they have no case in court. There is a record of all complaints of whatever nature that have been made to the water

department and about the water department for the past five years. These are arranged by years in 3 by 5-inch card files, and are the original records. All calls are recorded on the same size cards, three colors being used to distinguish between complaints relating to meters and bills, complaints and job orders relating to the mechanical division, and those relating to delinquent bills. This record is very valuable in refuting unjust accusations, in tracing past records, and for the purpose of settling especially difficult problem.

All complaints concerning high bills are investigated and a comprehensive written report is made to the consumer. The nature of the complaint is written on the card provided for that purpose and is given to an inspector who makes a specialty of investigating high bills. It has been found impracticable for the meter reader to waste time making investigations. He notes all unusual sounds or evident leakage on the reading slip and a special call is made. Sometimes a consumer is dissatisfied even after a second investigation, and he is allowed to hold the payment of the bill until the next quarterly statement, when he will see for himself the result of stopping small leaks. If, however, a rebate is yet expected or sought, a final notice of "Shut off for non-payment" is issued and the water is shut off in spite of threats of litigation.

For the purpose of determining the cause of persistent high bills, where "there are only two in the family, no leaks, and there is no sprinkling done; while the family next door has three or four children, does its own washing, sprinkles the lawn all day, and has only minimum bills," the department has evolved a recording detector which is substituted for the meter and which gives a graphic record of the consumption for twenty-four hours or a week. It is thus possible to spot the number of times the faucets are opened, the number of baths with the quantity used each time, and the number of times the toilets are used. It has thus been possible on many occasions to show that the toilet valve would not work about every fifth time it was operated, and that the lady of the house was apparently too clean, having the habit of letting the water run in the kitchen sink too long each day or that somebody took a cold bath every morning and consumed about 50 gallons each day in the operation, or that a thermostat used by a central heating plant leaked at some time during the day, or that the toilet was used too often to wash down foreign substances that did not belong there, or finally that the servant was very wasteful.

The complaints on account of high bills dropped in number from 2000 in 1913, to 600 in 1917, due to the education of the consumers who, realizing that the department means business, is strictly impartial and is able to help them reduce their water bills, have begun to coöperate with the department.

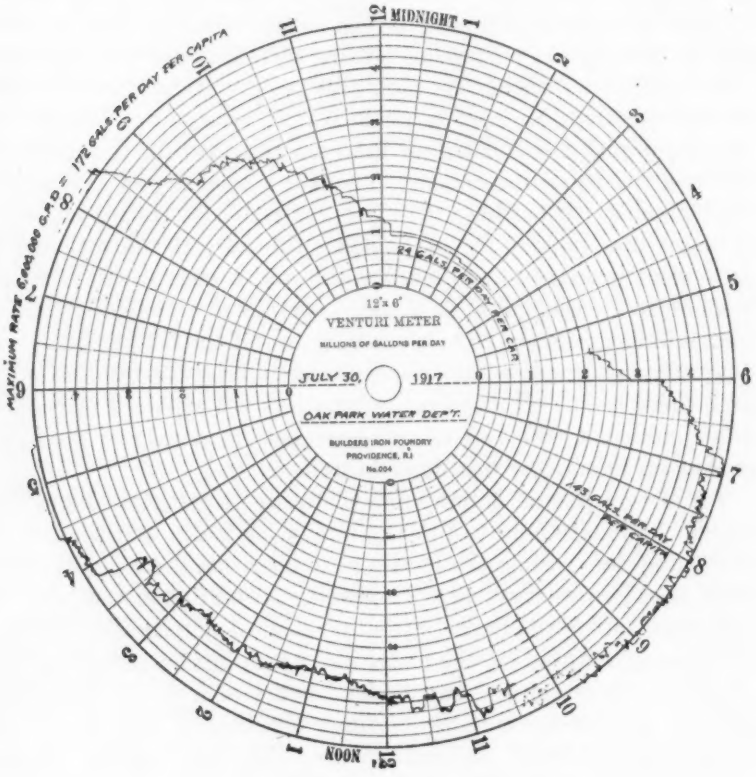


FIG. 3.

The third item in the efficient elimination of waste is the installation of recording pressure gauges and a master meter directly on the distribution system. The combination of the two devices is a great aid in estimating the rate of consumption during the night, which is due to leakage alone, in noting the progress each day in the stoppage of leaks, and in determining the necessity for making a special waste survey. The efficiency of the pumping station attendants as well as that of the pumps can be determined at a glance.

Many plants are equipped with Venturi meters or pitometer recorders placed on the main leading to filter beds, or to reservoirs or standpipes. The character of the consumption cannot be accurately determined by meters so placed that the fluctuations cannot be seen.

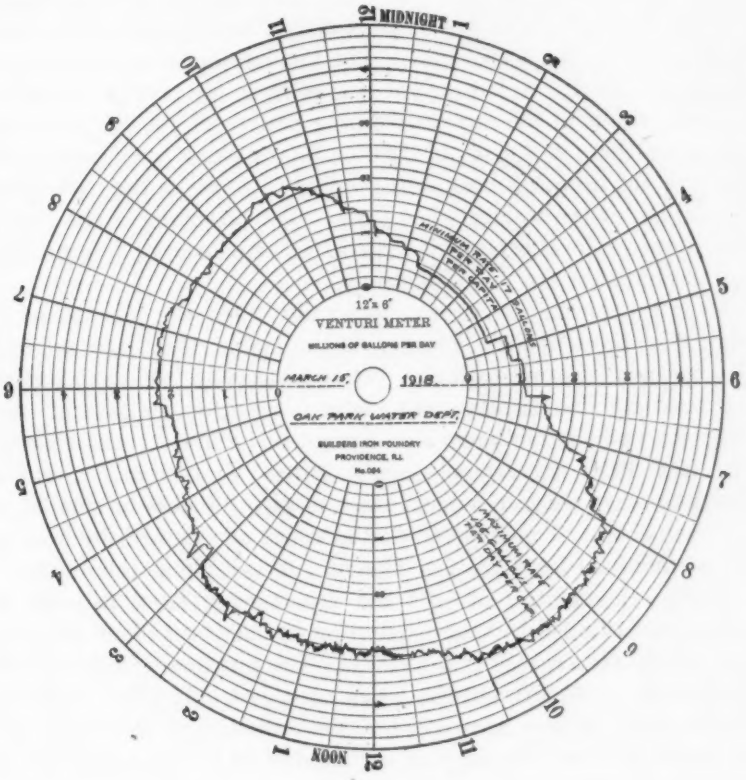


FIG. 4.

The waste survey, one of the most important elements in the prevention of continued needless waste on a metered water system, is next on the list, and the author hopes to see it become more popular.

In order to shorten the work of making waste surveys and avoid unnecessary work, it is advisable to make first a rough survey of the entire city with a pitometer, which is done by isolating certain districts and measuring all the water consumed through one of the

mains as a feeder. Here is where the master meter on the distribution system comes into use. The Oak Park department often shuts down large districts for a few minutes and notes the drop on the Venturi chart. It is impossible to do this at night because the quantity is only 400 gallons per minute between the hours of 1 and 4 a.m. In fact the smallest pump is so throttled in order to maintain the assumed pressure of 40 pounds that the opening left is equal in area to that of a 2-inch pipe. The Venturi meter is not sensitive enough at that low velocity; but it is possible to accomplish nearly the same result in the day time during periods of steady consumption when there is a draft of 2000 or 3000 gallons per minute. In this case the drop has been found sufficient to allow the making of an analysis of the leakage conditions. The pitometer is the surest way, however, for it is possible with it to obtain accurate information and so eliminate the "good districts."

After the pitometer survey, especially when the leakage is so small that there is little velocity in the mains, the "hydrant and hose method" follows logically. It is practically useless to expect any headway if a displacement meter is used, as the rate of consumption and the minimum flow cannot be accurately determined. The Oak Park department uses a 2-inch Venturi meter, but a pitometer inserted into a short piece of pipe 2 inches or smaller in size is as good. A manometer and as much condemned fire hose as can be obtained from the fire department, completes the outfit.

During the summer of 1917 the department tested 18 miles of mains, and stopped leakage amounting to 220,000 gallons per day. This represents a saving in the cost of water purchased from the city of Chicago, of $5,000 and the outfit used cost only $150, exclusive of the hose. It also accomplished the reduction of the night rate of consumption to the assumed standard of 20 per cent of the average daily consumption.

It has been the Oak Park experience that in order to be most efficient, a water department must be under one head. That is, not only should the manager take care of the mechanical end of the water works system but also the financial part. He should also inaugurate the policies. It is very difficult to handle complaints regarding high bills and to give satisfaction if the money is collected in one department, "shut-offs" for non-payment of bills are handled in another, and the bills are rendered in either of the foregoing or yet in a third one.

It is trying for the superintendent or manager to make a decision and be obliged to back down if the complainant is able to obtain a concession from someone higher up, who is not vitally interested in the efficient operation of the department and yields to pressure from some political adherent. It is difficult to enforce ordinances or rules if exception must be made in the case persons of influence or important political henchmen. It is impossible to prevent needless waste of water if certain organizations or institutions, by vote of the municipal authorities, are allowed free water against the advice of the manager.

The author acknowledges that absolutely nothing could be done toward the efficient management of the Oak Park water department were it not that the municipal authorities are intelligent business men who investigate all complaints thoroughly before acting upon them, and stand back of all the department's apparently arbitrary decisions, which, though they may cause temporary bad feeling, make for the betterment of the department. In short the department is able to live up to the water ordinance to the letter. It is not a mere scrap of paper.

A PRELIMINARY ANALYSIS OF THE DEGREE AND NATURE OF BACTERIAL REMOVAL IN FILTRATION PLANTS[1]

By Abel Wolman

The determination of a law of bacterial removal by rapid sand water filtration plants is of great practical importance and utility. Such determinations of plant efficiencies are valuable as indicators not only of present but also of future performance. The objection is, however, often justly raised against the attempt to predict quantitatively the possibilities of bacterial removal, that existing numerical measures of performances are misleading and in some cases even harmful. The calculation of percentage removal from raw water to effluent is an illustration of the type of measure which has arithmetical accuracy, but little logical basis. It is quite evident, however, that it would be desirable to measure quantitatively the performance of a plant in such a way as to obtain a comparative conception of how well or how badly it is being operated.

Since at present no agreement exists among operators, designers, or public health officials as to a standard of "good performance," because, in the past, agreement has been prevented by the interminable search for a "standard effluent," itself the subject of disagreement, it becomes necessary to attack the problem of rating or standardizing plant accomplishment from another angle. In this discussion, an initial search is made for certain basic characteristics of rapid sand filtration. The term, rapid sand filtration, is here used more broadly than usually, to describe the entire process from preliminary coagulation through sedimentation or settling, filtration, and disinfection.

The measure of variable phenomena by comparison with ideal or "normal" conditions is a procedure common to scientific analysis. The application of this method offers here a fruitful means of testing our ideas of filtration efficiency. The first problem obviously consists in the attempt to determine a possible correlation between the

[1] Read before the St. Louis Convention, May 15, 1918.

number of bacteria in the final effluent of a filtration plant and the number in the raw water. A numerical statement of the problem should be clearer. If a plant uses a raw water containing 500 bacteria per cubic centimeter and produces an effluent containing 10 per cubic centimeter, will the same plant produce an effluent of 20 per cubic centimeter when the raw water content is 1000 per cubic centimeter? Can one predict, in other words, with any degree of precision, what effluent counts should be normally attainable with varying raw water counts?

The use of a "percentage efficiency" is of but little value in the solution of this problem, since that measure is predicated upon the very assumption that the effluent counts vary directly, rather than more complexly, with raw water counts. The fallacy in this view need hardly be demonstrated at this late period in the development of filtration practice.

The norm or ideal performance from which it is possible to obtain hypotheses as to standard empirical accomplishment is not difficult to deduce. The "normal empirical performance" may be defined as the accomplishment of a filtration plant which is known to be operating successfully. Successful operation can be said to exist wherever there is an unquestioned superior bacteriological and physical quality of effluent, consistent performance, excellent control, and scientific observation of operating details. Plants whose performance may be used as the basis for comparison and for the derivation of the law of bacterial removal, are not at all rare. In this analysis, the operating statistics of the filtration plant at Avalon, Maryland, owned by the Baltimore County Water & Electric Company and operated by S. T. Powell, were used.

This plant obtains its raw water from the Patapsco River, a highly polluted stream, ranging in turbidity during the year from 0 to 5000 parts per million and in bacterial content (20°C. gelatine-48 hours), from several hundred to 150,000 per cubic centimeter. The watershed of the stream is composed largely of cultivated areas, with no large sewage polluting influences. This water is treated with aluminum sulphate, at an average rate of 0.8 grain per gallon, and is then allowed to settle for four hours. After leaving the sedimentation basin it is treated with calcium hypochlorite with an average dose of 0.34 part per million, and then passes through the rapid sand filters which have a capacity of 2,500,000 gallons per day.

The plant is controlled scientifically by a trained operator with the aid of modern equipment and laboratory observation. During several years of operation the bacterial content of the effluent has not exceeded, at any time, 20 bacteria per cubic centimeter. Presumptive tests for B. coli in lactose broth have indicated positive tests in 1 cc. less than 2 per cent of the time during any year. The

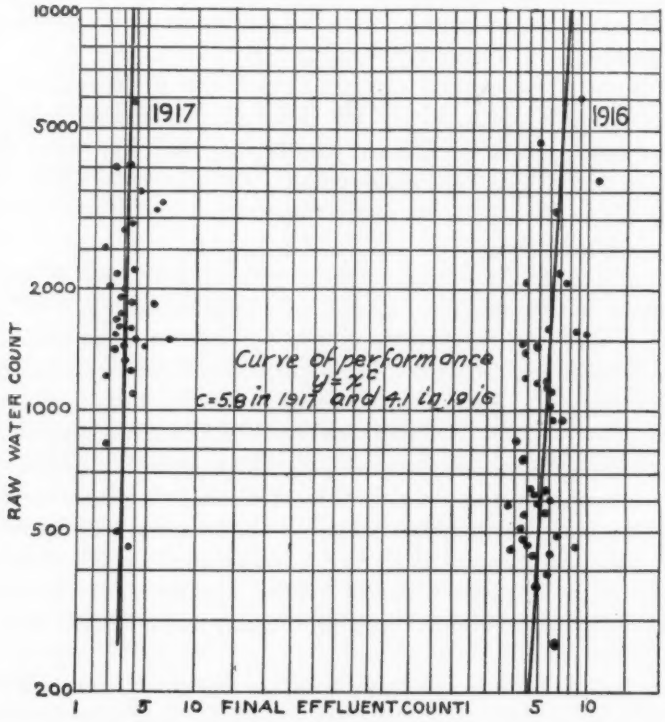


FIG. 1. BACTERIAL REMOVAL BY THE AVALON RAPID SAND FILTRATION PLANT DURING 1916 AND 1917; 20°C. BACTERIAL COUNTS USED

number and kinds of bacteria are determined in raw water and final effluent every day and general experimental data are constantly collected.

It is clear, therefore, that the plant in Baltimore County approaches so closely, from the standpoint of operating results, the ideal plant as to justify the use of its performance as the basis of a law of filtration.

In order to determine with some degree of accuracy the form of a characteristic empirical performance curve, the results of raw water and final effluent counts of the Avalon plant were plotted on figure 1.

In order to avoid plotting a mass of points which would tend to confuse the reader, seven-day averages of both stations, rather than daily results extending over a period of nineteen months in 1915, 1916, and 1917, were used. In plotting these values, approximately 520 daily analyses were summarized. These were obtained in consecutive months and under every phase of operating conditions. No counts were discarded as being unfair or incorrect. Figure 1 represents, therefore, the normal daily performance of the plant for more than a year and a half.

A study of the samples plotted on figure 1 reveals at once a consistency of arrangement. It is clear, too, that the performance of this normal plant is represented by the curves shown on figure 1. Inasmuch as these curves are practically straight lines, within the limits shown, the derivation of their equation is simple. The equation of a straight line, when the results have been plotted on a logarithmic basis, is given by: $c = \log y \div \log x$, where c is a constant for this particular plant, and y and x are respectively the raw water and final effluent counts.

It would appear, therefore, that the "normal empirical performance" is represented by a curve having the equation: $y = x^c$. A tentative hypothesis, with regard to bacterial removal by filtration action, may be promulgated, therefore, as follows: The final effluent count, under normal operating conditions, is an exponential function of the raw water count. This hypothesis provides a means of determining whether or not a plant under scrutiny is, at least, "performing normally," where normal performance would be interpreted as conformity to the logarithmic curve of filtration. Figure 2 illustrates, for instance, the failure of plant A to perform its function efficiently. By comparing the points on figure 2 showing the operating statistics of plant A with the points and the form of resultant curves in figure 1, it becomes clear that the plant A is erratic in performance in so far as the graphic representation of its operation departs from what we have reason to believe is a characteristic form of ideal curve of bacterial removal.

The "normal performance" curve demonstrates the fallacy of assuming that the *difficulty* of removal of bacteria is relatively the same regardless of the number of bacteria in the raw water. Although this assumption is rarely publicly proclaimed, it is usually summoned, however, to the aid of those plants which, for one reason or another, are so unsuccessful as to require a specious hypothesis,

fairly reasonable to the layman, to support their claims to maximum efficiency of 99 per cent plus. The practical results of a scientifically controlled plant certainly seem to lead to the conclusion that increases in raw water bacterial content decrease the corresponding bacterial content *interval* in the final effluent.

It should be added, too, that the equation of normal performance, $y = x^c$, offers a new quantitative measure of the efficiency of any plant, obtained by evaluating in any case the constant, c. Such a

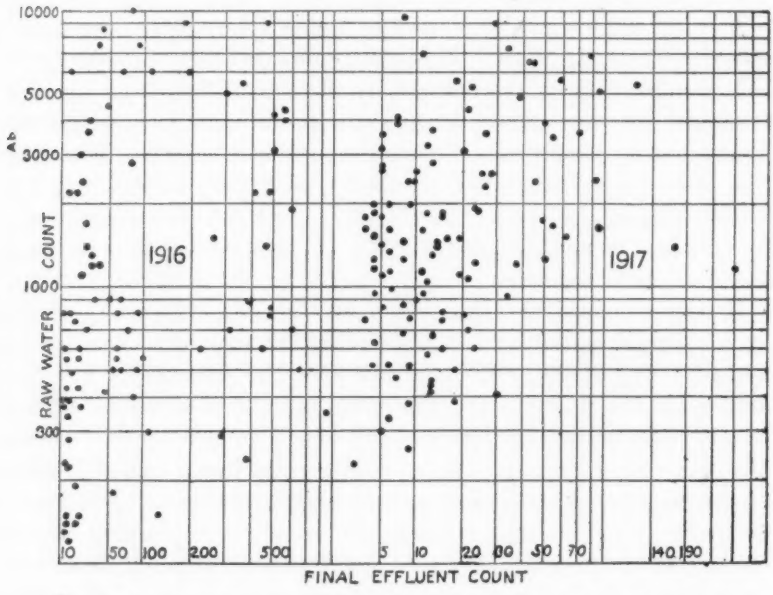


FIG. 2. INCONSISTENCY OF PERFORMANCE OF PLANT A AS INDICATED BY 20°C. COUNTS

measure, among other qualities, has the advantage of a rational basis and of a practical significance. Its use has been discussed elsewhere[2] by the author.

What absolute value this constant, c, or the so-called "coefficient of efficiency," should attain is dependent upon individual opinion of "good performance." It is of interest to note, however, that, in a survey of 19 rapid sand filtration plants, varying in size from 2.2 to 80.0 million gallons filtered per day, the coefficient of efficiency of these plants has attained an annual average of over 2.5. The raw

[2] *Jour. Amer. Pub. Health Assoc.*, November, 1916.

waters which these plants had to treat contained turbidities ranging from an annual average of 1 to 561 parts per million, and average bacterial contents from 350 to 16,500 per cubic centimeter. The 19 plants chosen, therefore, for the evaluation of c, are representative, in their initial conditions, of rapid sand filtration.

The probable existence of the law of filtration, $y = x^c$, combined with known values of c, practically attainable, gives the investigator

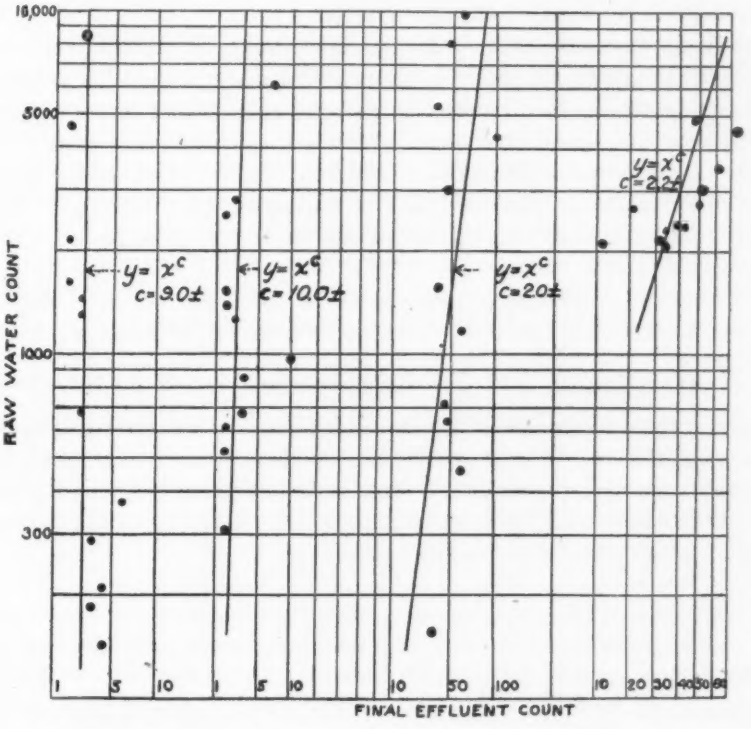


FIG. 3. PERFORMANCE CURVES OF FOUR LARGE RAPID SAND FILTRATIGN PLANTS

of filtration plant accomplishment the fundamental criteria with which to measure both the character and the amount of removal in any particular plant. The objection may be raised to the above method of critical standardization of plants, that all do not function in a similar manner, on account of differences in raw water, resulting from peculiarities of suspended matter, variations in resistance of

bacteria, and other similar factors. This objection does not seem to the author to be entirely valid, since peculiar characteristics of raw water are usually provided for by variations in design, such as increased periods of sedimentation and greater doses of disinfectant. It is reasonable to suppose, therefore, that given plants, initially properly designed for local conditions, should function according to some common law, since death rates under disinfection, devitalization and sedimentation and filtration of bacteria differ in the degree, but not in the kind, of changes effected.

The preliminary theory of bacterial removal by filtration is supported by the curves shown in figure 3, where are plotted the average monthly results from several large rapid sand plants in the United States. The monthly, instead of the weekly, results are used since the latter were not obtainable. The form of curve would be the same in both instances, while the value of the constant may change. It is quite obvious that each plant follows in its performance the characteristic $y = x^c$ curve.

Since the death-rate of bacteria under the action of disinfectants, and under well defined conditions, has been shown,[3] to follow in general the law: $c = \frac{1}{t_2 - t_1} \log \frac{y}{x}$, it will be necessary to look for the causative factors of the $y = x^c$ law in other phases of the system of rapid sand filtration. It is the author's purpose to study further the bacterial removal in the individual and distinct processes of coagulation, sedimentation, and filtration proper, with a view to throwing further light on the problem of causation.[4]

[3] H. Chick, *Jour. of Hygiene*, Vol. 8, 1908; Vol. 10, 1910.

[4] Strictly speaking, the equation of a straight line curve plotted on logarithmic axes is: $y = bx^c$, where b is the intercept on the y axis. In that case, c becomes $\frac{\log y - \log b}{\log x}$ rather than $\frac{\log y.}{\log x}$ Log b is infinitely small in our particular problem, since b, the intercept on the y axis, would be equivalent to those raw water counts which produce resultant final effluent counts of one. Since zero counts are rarely obtained in filtration plants, even with extremely low raw water counts, it is conceivable that the performance curve in the "normal operation" described above would intercept the y axis at some point approaching unity. Log b, therefore, would approach zero and could be neglected in the evaluation of c. It is evident, therefore, that $c = \frac{\log y}{\log x}$ measures in each case, with sufficient accuracy, the slope or inclination of the performance curve, the significant index to the efficiency of bacterial removal.

SOME ASPECTS OF CHEMICAL TREATMENT AT ST. LOUIS WATER WORKS[1]

By A. V. Graf

The principal streams contributing to the water supply of the city of St. Louis are the Mississippi, Illinois and Missouri Rivers. The Illinois River enters the Mississippi 33 miles north of the intakes at the Chain of Rocks and in traversing this distance a more or less intimate mixture of the two waters is effected. The Missouri River enters the Mississippi 5½ miles north of the intakes and causes a pressing of the Mississippi River water upon the east bank of the river and in this way, as a rule, very little mixing of the two waters occurs by the time the water reaches the intakes. At times the turbidity of the water on the west side of the river is ten times as great as that of the water on the east side, and at other times the color of the east water is 25 parts per million greater than that of the west water, showing the incompleteness of the mixing of the two waters. With a high stage in either river and a low stage in the other, the mixing of the waters is more complete.

The waters in each of these rivers have certain characteristics which become of greater or less interest as the stages of the rivers vary. The Mississippi River drainage area being covered with swamps, the water in this river becomes highly colored at times of heavy run-off, while the Illinois River, carrying a large amount of sewage, contains colloidal organic matter which seems to act as a protective colloid on the turbidity carried by this river. The water in the Missouri River, always turbid, becomes much more so at times of heavy run-off. The dissolved solids in these waters vary considerably but dissolved solids offer no difficulty in the treatment of the water and are therefore of less interest.

The river water enters the plant through two intakes, one, the old or west intake, 1500 feet east of the west bank of the river and connected to the wet well by a 7-foot circular, brick-lined tunnel, 2197 feet long. The other, or east intake, is 700 feet east and 200

[1] Read before the St. Louis Convention May 15, 1918.

feet north of the west intake and is connected to the wet well by an 8-foot circular, concrete-lined, tunnel 2747 feet long.

The water drawn through the west intake is principally Missouri River water for the greater part of the year, while the water drawn through the east intake is that of the mixture of the Mississippi and Illinois River waters, although at times the water at both intakes is practically the same both chemically and physically.

The east intake was in service only ninety-seven days during the past year whereas the west intake was used for three hundred and fifty days. Because of the greater difficulty of treating the water from the east intake, this is not used unless low stages of the river or anchor ice, or both, are affecting the pumping.

The water entering the tunnels flows by gravity to the wet well, whence it is pumped, against a dynamic head of 58.3 feet, into the delivery well and flows from there to the grit chamber where the average velocity of flow, at a rate of pumping of 150,000,000 gallons per day, is only 0.33 foot per second. In this chamber the coarser and heavier part of the suspended matter is deposited, the amount removed depending upon the character of the suspended matter as well as upon the amount present in the water. The efficiency of the grit chamber is shown in the fineness of the material removed, over 50 per cent of the matter deposited passing a 100-mesh sieve. The tons of matter removed by the grit chamber during the past year was 63,703 or 23 per cent of the total suspended matter present in the water.

Leaving the grit chamber, the water flows through a short conduit to the mixing chamber, where milk of lime and a solution of sulphate of iron are added. These chemicals are prepared in the coagulant house for addition to the water and are pumped a distance of 900 feet to the mixing chamber.

The lime is weighed out in automatic scales and is dumped into circular slaking tanks which are provided with revolving rakes. The temperature of the milk of lime in the slaking tank is kept at 200°F. This is accomplished by keeping up the temperature of the fresh water supply by passing it through the coils of a heater tank into which the milk of lime at 200° is drawn. From 4 to 4½ pounds of water per pound of lime are used in slaking. The water overflowing from the water tank is run into a cooling and diluting box, where the temperature is reduced to as low as 64° in winter time to 108° in summer. The strength of the milk of lime as pumped is 38,600 parts per million of CaO.

A slaker tank is kept in service until the accumulated unslakeable material is great enough to impede the motion of the rakes. From 50 to 150 tons of lime are slaked before a tank is taken out of service, the amount depending upon the purity of the lime. Tests made to determine the effect of limes of varying percentages of CaO upon the amount of lime that could be slaked before a slaking tank had to be taken out of service, showed that for every increase of 1 per cent in the available CaO, above the lowest lime tested, an additional 10 tons could be slaked. Contracts for lime are let under a specification requiring a lime of 85 per cent CaO, with a bonus or penalty of 1.5 per cent for each 1 per cent above or below the required 85 per cent.

The sulphate of iron is measured by passing it through an adjustable orifice onto the surface of a cylindrical drum, revolving at a constant speed and is discharged in a continuous flow into a tank, where it is dissolved without stirring, by water entering through a manifold at the bottom of the tank, the solution being drawn off through an overflow.

The mixing conduit into which the chemicals are delivered is a reinforced concrete box, 2382 feet long, 32 feet 1 inch wide and 12 feet 6 inches high, divided longitudinally into four compartments, each 7 feet wide and 11 feet high. The four compartments are supplied with stop-plank openings so that they may be thrown in parallel, used in series or withdrawn from service for cleaning. In normal operation the water enters the west channel and travels the full length four times, a total of 9528 feet, having an average velocity of 3.3 feet per second when the rate of pumping is 150,000,000 gallons a day.

Provision is made so that the lime or iron may be added to either of the four compartments, but the lime is added, for the greater part of the time, to the raw water as it enters the mixing conduit and the sulphate of iron as it leaves the conduit. The period of mixing averages about one hour. The sides and bottoms of the first two compartments are badly coated; the coating on the sides is practically all calcium and magnesium carbonates and magnesium hydroxide while the bottom coating consists of the sand and unslakeable material present in the lime added, bound together by the precipitated calcium carbonate and magnesium hydroxide.

The value of the mixing chamber is shown by an occurrence of last year. A leak in the south end of the mixing conduit, due to the failure of the contractor to properly plug a drain, caused the conduit

to be taken out of service. The water was passed from the delivery well direct to the first of the sedimentation basins, the sulphate of iron being added in the tunnel at the coagulant house and the milk of lime at the delivery well.

The turbidity of the water in the delivery well was 2500 at the time and the turbidity of the water in the last of the sedimentation basins was 20, the amounts of chemicals added being 6.25 grains of lime per gallon and 0.25 grain of sulphate of iron. After the mixing conduit was taken out of service, the sulphate of iron was increased to 2.50 grains per gallon, the lime remaining the same. In forty hours the turbidity of the water, in the last of the sedimentation basins, increased to 40, the turbidity of the river water remaining practically the same as on the preceding days. By adding ten times the amount of sulphate, the results were still inferior to what was accomplished with the mixing conduit in use. The additional cost due to the use of a larger amount of sulphate of iron while the conduit was out of service, one and one-half days, was $390.

The points of application of the milk of lime and sulphate of iron depend upon the condition of the raw water. With a water high in color and low in turbidity the iron is added before the lime with good results. If the high color is accompanied by a turbidity of 200 to 300 parts per million, better results are obtained by adding the sulphate of iron as the water leaves the mixing conduit. With high turbidity the lime is always added at the first opening and the sulphate of iron at the last. With low color and low turbidity due to colloidal matter, the sulphate of iron is added at the third opening, which allows a mixing through one-half of the conduit. At times with finely divided suspended matter in the raw water, the only sedimentation that takes place is accomplished in the first basin, the turbidity of the water in the last of the sedimentation basins being as great as that of the water leaving the first basin.

With high stages in the Mississippi and Illinois Rivers and a low stage in the Missouri, the worst condition is encountered. The high color of the Mississippi together with the colloidal matter in the Illinois make a water hard to handle. The use of sulphate of iron, as a coagulant, at these times is accompanied by some difficulty. The coloring matter of the water combines with the iron and instead of a diminution in color, the color is increased. The suspended matter being really colloidal and some of the iron hydroxide remaining in the colloidal condition, the turbidity of the water after sedimentation is

greater than that of the river. This highly colored and turbid water is much less amenable to treatment with sulphate of alumina. The amount of sulphate of alumina required to give the required flocculation of the suspended matter is from 4 to 5 grains per gallon. With this large amount of sulphate, the water passing the filters is clear but is still of high color, the iron content being eight to ten times as great as normally. At times when this condition occurs, no relief is experienced until the Missouri River run-off increases and thereby gives a turbid water which offers enough suspended matter for the rapid subsidence of the floc of ferric hydroxide. The more turbid the water at the intakes, the less trouble there is with turbidity causing material remaining in suspension.

After passing through the mixing conduit, the water enters the first of six sedimentation basins, each 400 feet long by 670 feet wide, of 30,000,000 gallons capacity. The first three division walls have five stop-plank openings and the last two four openings, all 4½ feet deep by 8 feet long. These openings render the sedimentation basins less efficient than would wiers extending the full width of the basins, but because of the necessity of maintaining an elevation of the water but little lower then the top of the basins, the need of stop-plank openings at times of cleaning is apparent. The time of sedimentation, based upon the capacity of the basins, varies from thirty to forty-three hours, but the actual time is much less, the effects of a change in the amounts of chemicals added being noticeable in twelve to fifteen hours in the last of the basins. About 90 per cent of the suspended matter and bacteria are removed in the first basin and 9 per cent in the remaining basins.

The total amount of matter removed from the water during the past year, including the chemicals added and the dissolved solids removed, amounted to 326,775 tons or 484,111 cubic yards. Some of the mud was removed by opening the sewer gate for one-half hour at varying intervals but the greater part was removed from the basins by labor and teams. The teams are used to draw scrapers which cut off portions of the mass of mud and drag them to the central gutter, through which water is flowing. The men are provided with scrapers which are used as such and also as braces to keep small A-shaped boxes in place, as the mud drawn by the horses and the water used to aid in removing the mud are drawn by the boxes. The cost of the removal of the mud from the sedimentation basins, not including the cost of the water, was 0.762 cent per cubic yard for the past year.

The water leaving the sedimentation basins enters a collecting conduit and passes through two 8-foot Venturi meters and into a small secondary coagulation basin, connected to secondary sedimentation basins by stop-plank openings. The solution of sulphate of alumina is added at the throat of the meters and is automatically controlled so that the quantity added per unit is constant for any setting, regardless of fluctuations in the flow through the meters.

No mixing chamber is provided here because of the low permissible loss of head, namely, 1½ feet. There are two secondary sedimentation basins, one east of the filter plant and one north, each of which is connected to the influent flume of the filters. The time of reaction and sedimentation, based on capacity, is twelve hours with both basins in service and six hours with one. The water entering the secondary coagulation basins being usually of a turbidity less than 20, little sedimentation takes place. It is not expected that these basins will need cleaning for some years.

The water entering the filter plant is passed through 40 filters, each with a filtering area of 1400 square feet, of 4,000,000 gallons capacity. The filtering media consist of 30 inches of sand above 12 inches of graded gravel. The effective size of the filter sand as placed in the filters was 0.341 mm., with a uniformity coefficient of 1.81. The effective size has increased to 0.407 mm. and the uniformity coefficient has been reduced to 1.45 due to the coating of the sand grains by material having the following composition:

	per cent
$CaCO_3$	76.00
$Al_2(OH)_6$ and $Fe(OH)_3$	15.00
$Mg(OH)_2$	9.00

Liquid chlorine, in the form of chlorine water, is added after filtration in a chamber in which the filtered water from the three connections to the effluent flume is combined. Two conduits, one a 7-foot ½-inch steel tube, the other a brick and masonry conduit 9 feet high and 11 feet wide, are connected to this chamber. These conduits convey the water to the pumping stations at Bissell's Point and Baden. The bacterial reductions caused by the chlorine were far from satisfactory until a baffle was built in the chamber to aid in mixing the chlorine with the water.

The reduction in bacteria in the water flowing through the steel line is always less than in the water in the brick conduit. Charges

of chlorine great enough to give tests for free chlorine in the water in the brick conduit, three hours after treatment, give no test in the steel line three minutes after. The disappearance and ineffectiveness of the chlorine in the water entering the steel line is attributed to the steel of the line. The Electro Bleaching Gas Company supplies the liquid chlorine which is measured and controlled by the liquid type meter apparatus also supplied by this company.

The accompanying operation record for the year ending February 28, 1918, shows very clearly the kind of water treated, the improvement in the condition of the water for each step of the purification system, the amounts of chemicals used and other details of operation.

Cost of operations per million gallons, St. Louis

	1918	1917
Old purification plant:		
Lime	$2.79	$1.89
Iron	0.55	0.61
Operating and miscellaneous expenses	1.18	1.04
	$4.52	$3.54
New purification plant:		
Aluminum sulphate	$1.16	$0.79
Chlorine	0.27	0.14
Operating and miscellaneous expenses	1.32	1.12
	$2.75	$2.05
Total cost for purification	$7.27	$5.59

Pumping

	1918	1917
Chain of rocks	$3.20	$2.437
Baden	8.984	7.134
Bissell's Point	6.825	5.308

Operation Record for Year Ending February 28, 1918

Chain of Rocks filters

		Basins out of service	Days out of service	Remarks
Water pumped (Chain of Rocks) in million gallons	39,289.23			
Water consumed in million gallons	38,024.64	No. 1	24	Basins cleaned:
Water filtered	39,351.70	No. 2	24	No. 1 May, July, November, mud 128 inches
Water used in filter house operation	805.22	No. 5	11	No. 2, May, July, mud 87 inches.
Water used in coagulant house operation	97.95	No. 6	14	No. 6, November, mud 45 inches
Water used in basin operation (filtered)	278.49	No. 8	123	No. 9, August, mud 46 inches.
Water used in basin operation (unfiltered)	593.04	No. 9	9	
Water used in purification. Total	1,774.70			

Chemicals used

Description	Pounds	Grains per gallon		
		Maximum	Minimum	Average
Lime	30,147,933	8.00	4.00	5.371
Sulphate of iron	4,294,689	2.50	0.00	0.765
Sulphate of alumina (meters)	3,781,163	3.68	0.11	0.673
Sulphate of alumina (influent)	29,560	0.25	0.00	0.005
Sulphate of alumina (filters)	108,756	14 pounds per wash	0 pounds per wash	0.019 grains per gallon
Chlorine	74,516	4 pounds per million gallons	0 pounds per million gallons	1.89 pounds per million gallons

Variations in water

DESCRIPTION	RIVER WATER			SETTLED WATER			APPLIED WATER			WATER TO HS. PUMPS		
	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.
Stage of river	105	74.9	78.4									
Temperature	84	32	54									
Turbidity, parts per million	5,000	8	1,240	110	9	24	32	4	10	0	0	0
Color, parts per million	48	10	22	35	6	14	32	5	12	28	4	9
Suspended solids, parts per million	6,930	6	1,700							0	0	0
Dissolved solids, parts per million	468	190	310							370	150	215
Total solids, parts per million	7,210	400	2,010							370	150	215
Alkalinity total, parts per million	233	93	145	146	32	60	136	27	56	127	26	53
Alkalinity caustic, parts per million				8								
Alkalinity bicarbonate, parts per million	233	93	145	122		20	120	0	28	115	8	29
Hardness total, parts per million	304	116	193							188	66	108
Bacteria gelatine, per cubic centimeter	625,000	600	55,500	7,000	59	1.020	4.800	53	710	530	2	98
Bacteria agar, per cubic centimeter	27,000	110	7,300	450	15	97	290	9	57	57	2	11
Coli, per cubic centimeter	80	0.2	17.2			0.259			0.271			0.0106

Number filters in service..... 40
Number filtering hours.....343,743
Average rate filtration, million grains daily..... 85.39
Rate of wash, gallons per million.... 21,000
Number of washes..... 8.931
Per cent wash water used..... 1.56
Average gallons used per wash..... 78.990

Run of filter in hours:
Max. 206.75; Min. 6.92; Av. 50.2
Run of filter in million gallons:
Max. 22.63; min. 0.876; Av. 5..67
B. coli per cubic centimeter in effluent..... 0.0485
B. coli per cubic centimeter tap water average..... 0.0121
Bacteria agar. Tap water average.. 10

Bacteria agar effluent..... 16
Bacteria gelatine effluent..... 185

THE DOUBLE 48-INCH MANIFOLD AT BISSELL'S POINT, ST. LOUIS

By C. M. Daily

A brief history of the St. Louis water works will be given, to enable the reader to understand the changing and growing conditions leading up to the present state of affairs which requires flexibility in the pumping from no. 2 engine house at Bissell's Point. To obtain the desired flexibility a chamber containing a double 48-inch manifold is now under construction about 129 feet west of no. 2 pumping station.

In the history of the St. Louis water works, the four years between 1867 and 1871 formed a constructive period, during which time was built the new pumping station at Bissell's Point, consisting of an intake tower, settling basins, low-service pumping station, clear well and no. 1 high service station. During this same period the standpipe on Grand Avenue and Compton Hill Reservoir were constructed.

In 1884 a second standpipe at Blair Avenue and Bissell's Avenue and the second high-service station at Bissell's Point were built. Another construction period was from 1887 to 1895; during this time an intake tower, tunnel, low-service pumping station and six settling basins were constructed at the Chain of Rocks and a 9- to 11-foot brick conduit connecting the settling basins at the Chain of Rocks with the settling basins at Bissell's Point, having a total length of 7 miles, were built. A third high-service station was constructed at Baden, 3.4 miles north of Bissell's Point, in 1898, and in 1905 a storage reservoir at Baden and a 7-foot steel flow line connecting with the settling basins at the Chain of Rocks were built.

After the low-service station at the Chain of Rocks was in use the intake tower and the old low-service station at Bissell's Point were abandoned, the settling basins becoming storage reservoirs. The three high-service stations received their supply of water from the Chain of Rocks by gravity flow through a 11-foot brick conduit and a 7-foot steel pipe to Baden and through a 9-foot brick conduit from Baden to Bissell's Point. The loss of head was about 1 foot in 10,000.

The high-service stations at Bissell's Point carried 85 pounds pressure per square inch and supplied the lower sections of the city, Compton Hill storage reservoir floating on the line. Baden high-service station carries 125 pound pressure per square inch and supplies the higher portions of the city. A standpipe at Compton Hill, erected in 1899, is connected to the Baden line.

From time to time additional equipments were added to the three high-service stations until 1911, when it became necessary to increase the capacity of both the Baden and Bissell's Point service. At this time the stations were equipped as follows: At Baden there were six triple expansion crank-and-fly-wheel engines four of which are rated at 15,000,000 gallons per day, and two at 10,000,000 gallons per day, the continuous working capacity being about 50,000,000 gallons. At Bissell's Point station no. 1 there were three triple expansion crank-and-fly-wheel engines having a continuous working capacity not exceeding 38,000,000 gallons per day. At station no. 2 there were three walking-beam engines built between 1884 and 1887, each having a nominal capacity of 16,000,000 gallons per day, the continuous working capacity not exceeding 30,000,000 gallons.

The problem presenting itself in the Water Department at that time was to increase the output of both Baden and Bissell's Point service to meet the increasing demands. To increase the capacity of Baden station it would have been necessary to build an additional engine house and a long 36-inch service main to reach the center of the distributing area. At Bissell's Point station no. 2 the fact that the engines had a very low efficiency (about 65,000,000 foot pounds per 1000 pounds of steam) justified their replacement. The distance to the center of the high pressure distribution area being closer, requiring a shorter and therefore cheaper 36-inch main, the loss of head in the conduit being much less than in the 36-inch pipe made it more economical to pump from Bissell's Point, except in the northern and north-western part of the city, than from Baden. It was, therefore, proper from an economical standpoint to increase Bissell's Point station no. 2 rather than Baden station. The final decision was to change Bissell's Point station no. 2 to work on both the Baden service and the Bissell's Point service.

To carry out this plan the three old engines were removed and two 20,000,000 gallon Holly triple-expansion crank-and-fly-wheel engines were installed in 1913 and one 20,000,000 gallon centrifugal pump was installed in 1915. The three pumps were designed to work either on

Baden or Bissell's Point service. The three 36-inch discharge pipes from this station were used for the new engines; one of these 36-inch mains was connected to the Baden service near Grand Avenue tower and the other two mains remained on Bissell's Point service.

The plan to install two more 20,000,000 gallon engines in this station would require extending the present by-pass arrangement far beyond its present limits in order to maintain the desired flexibility of pumping. This would require more space than there is available for the purpose. After various schemes were proposed and studied, it was decided to make the necessary by-pass connections through a double 48-inch cast iron manifold, to be built in a reinforced concrete chamber located 129 feet west of no. 2 station.

The manifold is designed to accommodate five engines, as a maximum, pumping into either Baden or Bissell's Point service with any engine. It is composed of two parallel 48-inch flanged cast iron pipes 94 feet long, spaced 12 feet apart in a vertical plane and erected at right angles to the 36-inch mains from the pumping station. The Baden service mains connect to the upper manifold and the Bissell's Point service mains to the lower.

Each main from the station will be connected to both upper and lower manifold in a vertical plane by means of a Y-branch introduced into the main about 20 feet east of the manifold. Each branch of each main will have a hydraulic-operated gate valve inside the concrete chamber. These valves will be operated from the station, permitting the engineer to pump, at will, into the 85-pound or 125-pound service mains.

Three hand-operated and two hydraulic 36-inch valves are placed on the service mains leaving the manifold and four hand-operated 48-inch valves placed in the manifold are for the purpose of withdrawing part of the system for any necessary repairs or inspection. The manifold is designed for connecting five service mains; four mains are now in place. The present plan is to use the two central mains for Bissell's Point service and the north main for Baden service: the south main, being the new 36-inch steel line, for both Bissell's Point and Baden service, the by-pass valves for this purpose being located at a distant point.

The manifolds are supported on steel I beams, incased in concrete for protection, which rest on the side walls of the chamber. The chamber, whose top will be flush with the ground at the center, is 102 feet long, 20 feet, 4 inches wide and 18 feet, 8 inches deep, all inside

dimensions. The bottom is designed to distribute the weight of the chamber and manifold over the entire area, the side walls to act as a vertical beam designed to withstand water pressure on the outside or one-half that pressure on the inside; horizontal beams at the top of the wall transfer the reaction of the wall to struts or ties across top. The struts or tie beams act also as roof girders, on which rest removable reinforced roof beams which support the removable roof slab. The roof slabs are 5 feet, 8 inches by 5 feet, 2½ inches and 4 inches. thick and are provided with openings for eyebolt connections for use in handling. The bottom of the chamber is lower than the sewers in its locality, and the drainage is effected by laying a 12-inch cast iron pipe to the sump in the engine house, where the water may be collected and pumped into the sewer.

Actual work on the chamber was started March 25, 1918. The present plan is to make the excavation and build about 44 feet of the south end of the chamber without removing the mains within this area. The reason for this procedure is that the ground-water level varies with the stage of the Mississippi River, and should the river rise above 20 feet on the St. Louis gauge it would be impracticable, if not impossible, to unwater the completed excavation without incurring heavy expense. Another reason is a possibility of not being able to get all of the castings for the manifold before the demand on the pumping reaches a high point. As a matter of safety it was thought best not to cripple this pumping station by removing any part of the old mains until it was certain there would be no delay in immediately rebuilding the new permanent mains. The second step involves the removal of the old mains in the next section of 24 feet and building the chamber and manifold complete for this distance. The third step will involve the removal of the two north mains and the construction of the remainder of the chamber and manifold. Temporary connection may be made from no. 6 pump to the completed portion of the manifold, before the last step in the construction is started, should the demand on the station at the time warrant it being done.

As simple as the construction appears from the description given, the work is viewed by the Engineering Department as a difficult operation, due chiefly to the soft treacherous ground which must support the adjacent 36-inch cast iron mains under working pressure while the excavation is being made and the reinforced concrete manifold chamber is under construction.

The excavation is being made with a clam shell. The material is dumped into flat cars and transported by electric cars to points on the Water Works property where a fill is required, and unloaded by hand. The excavation is lined solidly with 2-inch lumber and braced across the pit. The mains encountered in the excavation are supported by columns changed from time to time in order to keep their footings well below the bottom of the excavation. The ground water is removed by a 4-inch pulsometer. So far very little trouble has been experienced in the construction, The work is being done by employees of the Water Department under the author's direction, Mr. John Allgeyer acting as superintendent of the work.

The estimated cost of the work is $74,000, divided among the various items entering into its construction as follows:

Cast iron pipe, fittings, valves, etc.	$49,620.00
12 inch cast iron drains	812.00
Excavation, shoring, pumping, bracing and back-fill 2000 cubic feet at $2.00	4,000.00
Concrete, 615 cubic yards at $12.75	7,841.00
Removing mains, relaying and connecting manifold	5,000.00
Miscellaneous work, 10 per cent	6,727.00
	$74,000.00

THE NEW 110-MILLION GALLON PUMP AT THE CHAIN OF ROCKS, ST. LOUIS

By L. A. Day

In order to meet an increased demand for pumping capacity at the low-service pumping station of the city of St. Louis, a contract was awarded for a new turbine-driven centrifugal pump having a maximum capacity of 110,000,000 gallons per twenty-four hours. This will bring the total capacity of this station up to 290,000,000 gallons per twenty-four hours, which will be adequate for some time to come. The new pump will be located in the center pit, there being three pits in all. There are at present two 30,000,000 gallon turbine-driven pumps in this pit. Room was made for the 60-inch suction valve on this pump by channeling off 3 feet of the ledge on the east side of the pit for its entire length north and south. This also provides enough room in the pit for the location of the necessary auxiliaries used in connection with the new pump. The ledge was cut from solid limestone. It was also necessary to tunnel a 60-inch suction line through the limestone for a distance of 40 feet to the suction well which is common to all engines in this station. In addition to the 60-inch suction valve which is located within the pit, stop logs are provided in the wet well for making repairs on the suction valve if needed. The operating floor of the pump pit is 12 feet above the bottom. An automatic push-button electric elevator is used to reach the turbine operating floor from the ground level of the pumping station, which is 45 feet above. The pump will be required to operate under varying heads as the river rises or falls. The average total discharge head will be 60 feet with a minimum of 45 feet and a maximum of 65 feet.

The discharge pipe will be 60 inch diameter and will drop below the floor and then rise vertically, paralleling the west pit wall. The pipe will be enlarged to 72 inches from a flanged Y, which is 60 inches by 72 inches by 42 inches, due to the north 30,000,000 centrifugal pump discharging its water through the same pipe. The new unit will be provided with a 60-inch hydraulically operated discharge valve close to the Y and the old unit with a 42-inch hydraulically operated valve

close up to the 45 degree leg of the Y. The 72-inch line will be extended to the delivery well, which is a common discharge well for all pumps in this station. A 72-inch cast iron Venturi meter tube with a 36-inch throat diameter, the largest cast iron Venturi tube ever built, will be installed just outside of the pumping station.

The pump will deliver from 80,000,000 to 110,000,000 gallons in twenty-four hours against any head varying from 45 to 65 feet. This range of flexibility could not be met entirely with governor adjustment, but will be obtained by opening or closing hand operated valves on the turbine; the speed of the unit thus obtained will be further controlled by an automatic governor. This governor will be of the oil relay type, designed to permit of adjustment while the unit is in operation to any point within the required range of speed, and after being adjusted will maintain the required speed within 2 per cent variation above or below.

The maximum brake horse power of the turbine will be 1550 and the maximum water horse power required, including all pipe friction, will be 1250; the speed of the turbine under these conditions will be 3717 r.p.m. When the pump is delivering 80,000,000 gallons of water in twenty-four hours under a total head of 45 feet the turbine will run at 2946 r.p.m. The pump speed will be lowered by means of reduction gears to 352 r.p.m. when delivering 110,000,000 gallons under 65-feet head, and to 279 r.p.m. when delivering 80,000,000 gallons under a 45-foot head. The guaranteed pump efficiency will be slightly above 80 per cent under all of the specified head and capacity conditions. The suction and discharge openings to the pump will be 48 inches and the 60-inch suction and discharge piping will be gradually reduced near the pumps to this diameter.

The turbine is of the multistage impulse type and will operate with 125 pounds gage pressure and 75° superheat. Provision will be made for bleeding 1500 pounds of steam from one of the low-pressure stages for heating feed water. Bleeding this amount of steam will increase the B.t.u. duty of the unit approximately 3 per cent. The bleeder outlet will be provided with an automatic valve set to carry a pressure of 5 pounds gage on the exhaust line at all times. The dry vacuum pump is of the horizontal crank-and-flywheel type designed to operate at a speed not to exceed 115 r.p.m. The condensate pump will be turbine-driven, connected to a centrifugal pump by means of reduction gears. The circulating pump will be direct connected to the main unit shaft, and will take its water from the 60-inch suction; after passing

through the condenser the water will be discharged back into the main suction pipe. The condenser will be of the water-tube type placed directly under the turbine. Water for circulating purposes only will pass through the condenser, as an excessive amount of friction would have been obtained by passing all of the water pumped by the unit through the condenser, this being the usual water works practice. In order to derive as much heat as possible out of the exhaust steam going to the condenser a primary heater will be placed in the condenser and all the condensate from the condenser will be pumped through this heater before going to the hot well or open feed-water heater. The total condenser surface will be 2825 square feet of seamless drawn brass tubes No. 18 B.W.G., 1 inch in diameter and 12 feet long.

The unit was bought on the bidder's guarantees of duty per million B. t.u. consumed by the unit, including auxiliaries and bled steam, with the provision that the total amount of exhaust steam from the auxiliaries, plus the steam bled from the unit, should not exceed 2200 pounds per hour.

The successful bidder's guarantees were as follows:

	100,000,000 GALLON			80,000,000 GALLON			110,000,000 GALLON		
Head in feet	45	60	65	45	60	65	45	60	65
50° circulating water	113.5	120	122	107	113.75	115	114	120.75	121.5
80° circulating water	106.5	113	115	101.5	108.50	109.5	107	113.50	114.0

The average duty for all of these conditions is 114,562,000 foot-pounds per million B.t.u.'s. which is equivalent to a duty of 134,000,000 foot-pounds per 1000 pounds of steam.

Attention is called to the fact that different duties are obtained with different temperatures of circulating water. This is due to the fact that if the turbine is designed properly, better economies will be obtained with low circulating-water temperatures, owing to an increased vacuum. The average circulating water temperatures for this station throughout the year are 50° for the winter and 80° for the summer. In order to compare bids on this unit the following information was embodied in the specifications:

> One million foot pounds of duty will be valued at $2000. That is, if bidder A guarantees 5,000,000 foot pounds higher duty than bidder B, $10,000 will be added to B's bid for comparison with A's bid.

Bidders were instructed to submit curves showing duties guaranteed when pumping 80,000,000, 100,000,000 and 110,000,000 gallons with circulating water temperatures of 50° and 80° and heads of 45, 60 and 65 feet.

During four-fifths of the time each year the pump operates, it is estimated that it will be called on to deliver from 80,000,000 to 110,000,000 gallons under heads varying between 60 and 65 feet. During the remaining one-fifth of the year, it is assumed this pump will deliver from 80,000,000 to 110,000,000 gallons under a 45 foot head. It was further assumed that the unit will deliver 100,000,000 gallons for one half of each year under all head conditions and the remaining half it will deliver either 80,000,000 or 110,000,000 gallons in equal parts.

The process may be represented diagrammatically as follows:

100,000,000 gallons daily

$$\frac{\text{Duty at } 50° + \text{Duty at } 80°}{2} \text{ for 45 ft. head x 1} = \ldots\ldots\ldots\ldots$$

Ditto for 60 ft. head x 2 = ...

Ditto for 65 ft. head x 2 = ...

$$5) \frac{\text{Sum}}{\text{Duty A}}$$

80,000,000 gallons daily

$$\frac{\text{Duty at } 50° + \text{Duty at } 80°}{2} \text{ for 45 ft. head x 1} = \ldots\ldots\ldots\ldots$$

Ditto for 60 ft. head x 2 = ...

Ditto for 65 ft. head x 2 = ...

$$5) \frac{\text{Sum}}{\text{Duty B}}$$

110,000,000 gallons daily

$$\frac{\text{Duty at } 50° + \text{Duty at } 80°}{2} \text{ for 45 ft. head x 1} = \ldots\ldots\ldots\ldots$$

Ditto for 60 ft. head x 2 = ...

Ditto for 65 ft. head x 2 = ...

$$5) \frac{\text{Sum}}{\text{Duty C}}$$

$$\text{Resultant Duty} = \frac{2 \times \text{Duty A} + \text{Duty B} + \text{Duty C}}{4}$$

All of the above conditions must be verified by complete shop tests before the unit is shipped. These shop tests must be on the turbine, gears and pump assembled complete. The shop tests must show duties at least those guaranteed by the contractor and checked by the city's representatives.

After the unit is installed it will be subjected to an endurance test of ten days of twenty-four hours each. A station duty test will then be made as a check on the shop duty test, the station test to be conducted entirely in accordance with recommendations laid down in the latest A.S.M.E code for testing steam driven pumping machinery. The capacity will be measured with a Venturi meter.

The physical data of the unit and auxiliaries is as follows:

Turbine

Make	DeLaval
Brake horse power of turbine	Normal 1300, maximum 1550
Number of stages	13
Number and diameter of rotors	4—27½ in.; 9—24 in.
Revolutions per minute under maximum conditions	3720
Method of speed control	Jahn's governor through oil relay
Percentage of speed obtainable above and below normal by governor regulations	6 above and 15 below
Percentage of speed obtainable above and below normal by hand-regulated nozzle	Approximately 6 above and 20 below
Net weight of turbine without bedplate, pounds	24,000
Diameter and length of bearings, inches	4½ x 14
Diameter of shaft in rotor, inches	10
Diameter of steam admission, inches	6
Diameter of steam exhaust, inches	36

Reduction gear

Net weight of reduction gear complete without bedplate, pound,	32,000
Diameter of driven gear, inches	63.4
Diameter of pinion, inches	6
Width of face of gear in pinion, inches	29¼
Tooth pressure per inch, face of gear and pinion, when pump is delivering 110,000,000 gallon per day at 65 foot head pounds	300
Gear ratio	10.56 to 1
Angle of gear tooth, degrees	45
Mechanical efficiency of gear, per cent	98
Horse power consumed by gear under maximum conditions	31

Pump

Net weight of pump without bedplate, pounds	40,000
Net weight of bedplate for complete unit, pounds	15,000
Diameter of impellers, inches	50
Diameter of shaft at impeller, inches	8
Diameter and length of bearings, inches	One $6\frac{1}{2}$ x 18, one $5\frac{1}{4}$ x 18
Length of shaft between bearings, feet	$8\frac{1}{3}$
Revolutions per minute, maximum	352
Diameter of water suction, inches	48
Diameter of water discharge, inches	48
Efficiency of pump, per cent (for normal conditions)	81

Condenser

Condensing surface, square feet	2825
Diameter of tubes, inches	1
Gage of tubes	No. 18 B. W. G.
Length of tubes, feet	12
Number of steam passes	1
Number of water passes	2
Size of exhaust-steam inlet, inches	36
Net weight of condenser, pounds	20,800
Diameter of condenser shell, feet	5
Length of shell, feet	$14\frac{3}{4}$

Air pump

Revolutions per minute	115
Size of inlet, inches	5
Size of outlet, inches	3
Method of driving air pump	By steam cylinders
Weight of air pump complete, pounds	6400

Condensate pump

Size of pump, inches	$2\frac{1}{2}$
Revolutions per minute	1800
Size of inlet, inches	$2\frac{1}{2}$
Size of outlet, inches	$2\frac{1}{2}$

SOME PHASES OF WORK IN THE DISTRIBUTION SECTION OF THE WATER DIVISION, ST. LOUIS

By W. A. Foley

There are several distinct features of the St. Louis distribution system which do not usually obtain in other municipalities; principal among these may be mentioned the two distinct distributing systems called the high and low. The topography of St. Louis is such that the city maintains these two systems, the first termed high at 125-pounds pressure, the second termed low at 85-pounds pressure.

The low system comprises about 67 per cent of the pipe mileage, and ranges in size from 3-inch to 48-inch, amounting to 680 miles, supplying approximately 35.4 square miles of area. This system supplies certain districts where the elevation does not exceed 100 feet above the city datum. It was installed before the confining limits of the city were extended, when the city proper was located on the table land adjacent to the river.

As the city growth pushed forward it was essential that the outlying districts be supplied with an adequate volume and pressure, and the topography of the land was such that an increased pressure system with high duty pumps had to be installed to meet the demand. The high-pressure district now comprising 330 miles of pipe was decided upon. This system supplies districts in which the elevation exceeds the city datum by more than 100 feet, and is equal in area to 26 square miles. The two systems are separate and distinct, although there is contiguity in all the mileage, the pipe system being laid out on the gridiron theory. Each is maintained separate and independent of the other by means of valves, which close off one system from the other, thus maintaining the independent pressures. The valves are termed separation valves, being kept closed and tabbed with metallic disks showing the number of each valve and indicative of the valve being shut. In the event a metallic disk is not readily available the cap-nut of the valve is reversed or inverted, which is also indicative of a separation valve.

These valves are not opened except when necessity arises, and in this event the high pressure is allowed to bleed into the low system

during the period the occasion demands. They are also opened during the semi-annual inspection of valves, which occurs in May and November, when all valves in the two systems are examined and worked to insure their thorough fitness for any subsequent operation, or as a relief to the crowding of the high service pumps, which occurs during the night, when a few separation valves are opened to relieve the load.

Many of the consumers are so fortunately located that either high or low service is available for domestic supply. The low-pressure extremes range from 30 to 85 pounds, and the high-pressure from 40 to 125 pounds. The business section of St. Louis, being the oldest, is supplied by the low pressure system, but ordinarily good pressure is obtained, the average for the commercial district, which comprises 483 city blocks or $2\frac{1}{3}$ square miles area, being 45 pounds.

Another feature of the St. Louis distribution system is a 36-inch lock-bar steel main in 30-feet lengths with riveted joints, 26,700 feet in length, which crosses the heart of the city, and acts as a carrier for either high or low-service feed. This feeder has its origin in the central pumping station and can be operated from an 85-pound head with a delivery of 750,000 gallons per hour, or from an 125-pound head with a delivery of approximately 1,000,000 gallons per hour. The change in this trunk line from high to low service is effected by the operation of a few hand-operated valves immediately in front of the engine house and two hydraulically operated valves at the terminus of the steel main, practically 5 miles distant, where it is breeched into both systems by means of a Y connection. In times of emergency or excessive draught, this feeder serves as a reserve or reinforcement of either system. Many other communities accomplish practically the same purpose by speeding up pumps in times of fire, but the St. Louis steel line was designed with the purpose in view of acting as a composite carrier on either system, as the need arose.

The essential necessity of present-day distribution is conservative despatch. Mechanical appliances to supplant slow hand labor and the execution of repair work with speed are the chief features of distribution work. Although all water distribution departments have features in common, with reference to the general work, yet each individual system has some little appliance or method of repair which is a special feature of that particular system.

Portable pumps driven by air or gas, such as Los Angeles has in service, trench filling by cable drag or auto slip, have been employed

in St. Louis, not by the exact method employed by other communities, but by methods which prove more feasible here. During the winter, when frozen soil conditions make the excavation for repairs of broken mains excessive in cost, the St. Louis Department has found it practicable to use a blast pan, such as is employed by street repair gangs in asphalt surfacing. This proves an effective method of dissipating the frost and expediates the work of excavation, consequently effecting a saving of both time and labor. In the repair of mains 15 inches in diameter and larger where such repairs necessitate the employment of a sleeve, the department finds it expedient to employ what is known as a sleeve-spacer. This simple device is the idea of a local street service foreman, and has proved of great value in such work. The spacer is a sort of turn-buckle affair, which is slipped into position and tightened, so as to prevent movement of pipe when the sleeve is slipped into place, but it serves an ideal purpose in spacing the sleeve so that an even joint can be run around the pipe circumference. Usually four of these spacers are employed in the repair of mains 30 inches in diameter and larger. This device is worthy of adoption, especially where repairs are made in close proximity to a valve and its subsequent closing with its large pressure surface may cause a creeping of pipe at the space where sleeve has been employed.

Constant attention to every detail is becoming absolutely essential for the maintenance of a modern pipe system. Air patrols to release air pockets, constant overhauling of valves and other appurtenances, and absolute attention are the prices demanded in a modern system. Conservation of water by the insertion of valves, so that no great loss of water will result from the scarcity of these necessary valves when shuts are enforced on a distributing system through broken mains, is essential. In St. Louis the practice of lengthy shuts for repairs was common until five years ago. These shuts are generally made in a residential district, and the inconveniences are many. Not only does the application of frequent valves mean a conservation of water, but it means inconvenience for fewer consumers, and the convenience of the consumer is the essential feature in water distribution.

Not only does the city of St. Louis study and apply all principles which tend to the betterment of the system, but the department maintains an intelligence bureau holding school for one week's duration twice per year. At these school sessions all employes of the distribution system attend, especially the newcomers, who are fully initiated in the art of cutting pipe, yarning and pouring joints, caulking,

assembling hydrants and valves, rigging derricks, the use and names of various tools, and all other little details with which all distribution employes should be familiar. These sessions are generally attended by department engineers, and often the exchange of ideas proves as beneficial to the superiors as to the subordinates. The professor in charge is generally a graduate of the ditch, who has advanced step by step in the service, and is capable of showing the principle by actual demonstration. By teaching the employes the use of tools and allowing them to do the actual work in these practice sessions, the department has always on hand an adequate corps of capable men who can assume the different positions without crippling the service when the occasion demands. All large cities should adopt the idea as it familiarizes the employes with the different methods and use of tools, which proves of inestimable value to the department when "trouble-time" arrives.

REPORT OF COMMITTEE ON WAR BURDENS OF WATER WORKS IN THE UNITED STATES

The Executive Committee of the American Water Works Association undertook to collect, for presentation before the annual convention of the Association, at St. Louis, May 13–16, 1918, information concerning the effect of war conditions upon the construction, operation and maintenance of water works in the United States. Replies to its call for information were received from about fifty municipally and corporately owned water works plants in the U. S. It was impossible to prepare this material in useful comparative form for presentation to the convention. A committee was therefore appointed to do this, which now presents its report.

GENERAL FINANCIAL CONDITIONS FACED BY WATER WORKS

Water works have suffered large increase in construction, operation and maintenance costs, due to war conditions. Marked decline in net revenue has resulted.

These conditions began to be generally felt late in 1916, but it was not until the latter part of 1917 that they became serious. Water works employees were true to their tasks; the desirability and continuity of their employment tended to stay the advance in their wages, which lagged behind the general advance in wages paid to labor, by a period of eighteen months, more or less. Men working in contractors' forces, in munitions and allied works, had long enjoyed very substantial, and in some war industries, abnormal increase in wages, before the increase came to water works employees.

But the advance in labor cost to American water works has gathered force in the last six months, and it is the general opinion of municipal and corporate managers that additional increases are certain to come during 1918 and thereafter, if labor is to be held. It is certainly undesirable to replace old well-trained forces, familiar with these properties, with other labor not having this familiarity, in the effort to hold the wages at a point below the general local standard for similar service. The character of the service would suffer. Serious and conscientious effort has been made by water

works operators generally, to reduce construction and operating forces and expenses to a minimum. These reductions have in many cases gone beyond desirable limits, even to reducing the working efficiency of the properties.

The general situation is a very serious one, from the point of view of the public, and an anxious one for the managers of water works. Already it has shown itself in increasing difficulty, and in many cases impossibility, of attracting capital to water works for necessary betterments. Moreover, it is inevitable that the Capital Issues Board will scrutinize more and more closely the diversion of funds to water works needs, particularly where those needs are not involved by governmental activities.

Pressure will doubtless be brought to bear to force communities to husband their water supplies, by reducing waste, leakage, and even unnecessary consumption, in order to curtail unnecessary investment in plant thus made necessary. No doubt, here as abroad, there may come a time when the smaller works will be unable to extend their service during the duration of the war, unless government needs be concerned, but it would be most unfortunate if the activities of an important city or of communities with manifold industrial and commercial industries were to be thus circumscribed.

The menace of the situation lies in the increasing difficulty, under such conditions, of maintaining constantly a water service, safe from a sanitary standpoint, necessary for good fire protection service, and adequate to industrial, commercial and domestic needs.

It appears clear that average pre-war prices will never again be realized and that the purchasing power of money has declined permanently the world over, as a result of the war, and will never be fully recovered. Present prices, which on most water works materials are double pre-war prices, and on labor 25 to 50 per cent greater, will probably not hold permanently after the war. Nevertheless, the old prices will not return as a whole.

The difficulty of the situation faced by utility properties in this country was clearly indicated in a letter addressed by the Secretary of the Treasury, Mr. McAdoo, to the President, on February 15, 1918, transmitting several memoranda prepared by committees of the American Electric Railway Association, The National Electric Light Association, the American Gas Institute and the National Commercial Gas Association, in which he called attention to the existence of genuine apprehension regarding the adequacy, under

present conditions, of the service and rates of local public utilities; that increased wages and high costs of essential materials and supplies have affected them, as they have affected everybody else; and that united effort will be necessary in order to meet alike the requirements of public service, and the corporate financial needs upon which that service depends. Concluding his letter to the President, the Secretary said:

> I earnestly hope that you may feel justified in expressing the conviction that the vital part which the Public Utilities Companies represent in the life and war-making energy of the nation, ought to receive fair and just recognition by state and local authorities.

President Wilson in his reply to Secretary McAdoo, dated February 19, 1918, said:

> It is essential that these utilities should be maintained at their maximum efficiency, and that everything reasonably possible should be done with that end in view. I hope that the state and the local authorities, where they have not already done so, will, when the facts are properly laid before them, respond promptly to the necessities of the situation.

Public Utility Commissions and other similar regulatory bodies n the United States have already shown their appreciation of the serious nature of the conditions confronting public utility properties, by granting increases in rates or the levying of surcharges on existing rate schedules in many cases, after careful review of the local conditions.

Valuation under present conditions is a very difficult, laborious and time-consuming task, and in view of the heavy burden of additional work under which these commissions are laboring, it is reasonable to believe that prompter consideration can be had by petitioning for relief, rather than for revaluation of property as a basis for change in rates.

How far these commissions will attempt to maintain the standard, heretofore avowed by them, of taking prompt action, to the end of reducing the unfair burdens of the people on the one hand and the hazard of investment and operation on the other, cannot now be determined. They may take the position that a portion of the abnormal expense, due to war conditions, must be borne by the works and a portion by the public, but in any event, it appears likely that they will not be insensible to pleas fairly directed toward the maintenance of corporate credit, and will recognize clearly that

it is not to the interest of the public to permit conditions which may destroy credit, and that credit seriously impaired or once destroyed cannot be re-established readily.

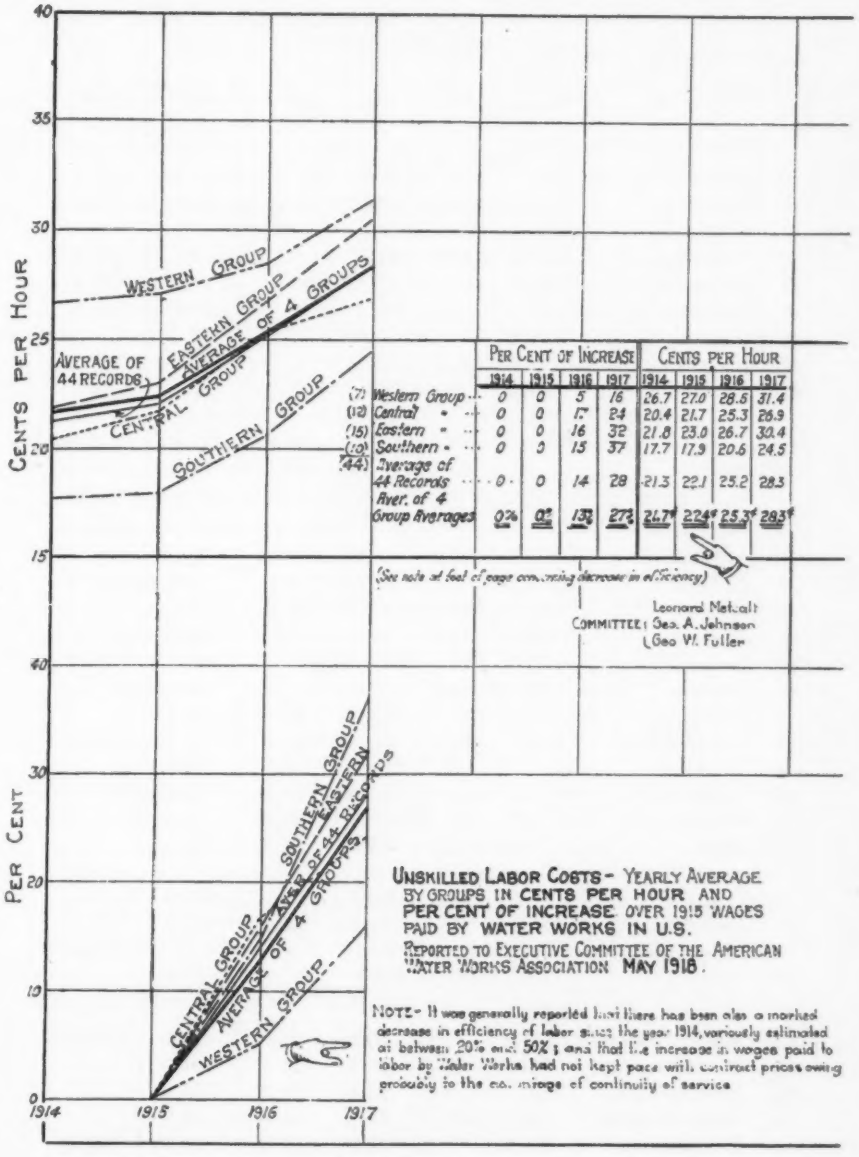
It was urged upon the members of the Association at the St. Louis convention, that the effort should be made to maintain operating efficiency, and that careful record should be made of change in cost of construction and operating materials and labor, so that if it should become necessary to make applications for advance in rates, on the part of either the municipally or the corporately owned works, the facts upon which the regulatory bodies could base sound judgment could be well established.

The following record of replies received from various municipally and corporately owned properties in this country, is submitted in tabular and graphical form, as evidence of the rapid change in conditions facing water works in this country from the years 1914 and 1915, which reflect the pre-war conditions, to the early part of the year 1918. All evidence points to yet more trying conditions for the future.

CONSTRUCTION LABOR AND MATERIAL COSTS

Advance in labor costs. Figure 1 shows the advance in the yearly average cost in cents per hour of unskilled labor to 44 American water works, arranged in four local groups. These indicate an average advance over pre-war prices prevailing in 1915 of 13 per cent in 1916 and 27 per cent in 1917, the fragmentary figures submitted for the opening of 1918 showing materially greater increase. It is important to note that comparison of past and present wage scales does not tell the whole story of increase in cost of labor to water works. Unfortunately, there has been marked decrease in efficiency. Your committee has made personal inquiry concerning this, within the last two months, from the managers of municipal as well as of corporate works, from the Pacific Coast to the East, and from the North to the South. In all cases, decrease in efficiency was reported. The estimates of percentage loss in efficiency, comparable with the efficiency of 1915 and prior thereto, varied from 20 to 50 per cent. The concensus of opinion seemed to range between 25 and 35 per cent.

It thus appears that the loss in efficiency of labor is practically equal to its increase in wage. The full increase in cost of labor,



		Per Cent of Increase				Cents per Hour			
		1914	1915	1916	1917	1914	1915	1916	1917
(7)	Western Group	0	0	5	16	26.7	27.0	28.5	31.4
(12)	Central "	0	0	17	24	20.4	21.7	25.3	26.9
(15)	Eastern "	0	0	16	32	21.8	23.0	26.7	30.4
(10)	Southern "	0	0	15	37	17.7	17.9	20.6	24.5
(44)	Average of 44 Records	0	0	14	28	21.3	22.1	25.2	28.3
	Aver. of 4 Group Averages	0%	0%	13%	27%	21.7¢	22.4¢	25.3¢	28.3¢

(See note at foot of page concerning decrease in efficiency)

Leonard Metcalf
COMMITTEE: Geo. A. Johnson
Geo W. Fuller

UNSKILLED LABOR COSTS - YEARLY AVERAGE BY GROUPS IN CENTS PER HOUR AND PER CENT OF INCREASE OVER 1915 WAGES PAID BY WATER WORKS IN U.S.

REPORTED TO EXECUTIVE COMMITTEE OF THE AMERICAN WATER WORKS ASSOCIATION MAY 1918.

NOTE- It was generally reported last there has been also a marked decrease in efficiency of labor since the year 1914, variously estimated at between 20% and 50%; and that the increase in wages paid to labor by Water Works had not kept pace with contract prices owing probably to the encouragement of continuity of service

FIGURE 1

TABLE 1

Unskilled labor costs—average during year in cents per hour. Paid by water works in the United States

REFERENCE NUMBER	STATE	POPULATION IN THOUSANDS	1914	1915	1916	1917	1918
			Western group				
45	California	575.0	25–28.1	25–28.1	28.1–31.3	31.3–34.4	31.3–37.5
46	California	523.0					
52	Washington	350.0	37.5	37.5			50.0
51	Oregon	275.7	37.5	37.5	37.5	37.5	40.6
47	Colorado	213.4	22.5	22.5	22.5	30.0	35.0
50	Kansas	67.8	17.5	20.0	22.5	27.0	
48	Iowa	27.1	25.0	25.0	25.0	30.0	
49	Iowa	14.0	20.0	20.0	25.0	25.0	
Total			186.7	189.0	199.7	219.9	
Average			26.7	27.0	28.5	31.4	
			Central group				
25	Michigan	678.7	25.0	25.0	28.0	36.0	
20	Indiana	269.5	20.0	20.0	22.0	24.0	25.0
26	Illinois	72.1	25.0	23.3	27.0	30.0	
31	Wisconsin	45.5	15.0	25.0	30.0	35.0	
24	Indiana	25.2	22.5	22.5	25.0	25.0	
21	Indiana	20.3	20.0	20.0	22.5	20.0	
29	Wisconsin	14.6	17.5	17.5	27.5	25.0	
28	Wisconsin	10.9	22.5	22.5	24.2	28.5	32.5
30	Wisconsin	8.8	20.0	20.0	20.0	25.0	
22	Indiana	5.6	17.5	20.0	25.0	22.5	
23	Indiana	5.6	17.5	20.0	25.0	22.5	
27	Ohio	4.0	22.2	25.0	27.7	30.0	
Total			244.7	260.8	303.9	322.9	
Average			20.4	21.7	25.3	26.9	
			Eastern group				
15	Pennsylvania	1,683.7					
1	Massachusetts	745.1	25.0	25.0	25.0	30.0	30.0
18	Pennsylvania	333.0	19.7	19.5	21.1	24.5	
16	Pennsylvania	150.0	18.0	22.5	29.0	35.0	
4	Massachusetts	110.0	31.0	31.0	31.0	24.0	
5	Connecticut	109.0	25.0	25.0	28.0	31.0	34.0
10	New York	99.4					
14	Pennsylvania	40.4	22.2	22.2	30.0	30.0	
9	New York	36.9	25.0	25.0	25–30	30.0	30.0

TABLE 1—*Continued*

REFERENCE NUMBER	STATE	POPULATION IN THOUSANDS	1914	1915	1916	1917	1918
			Eastern group—Continued				
11	Pennsylvania	26.6	20.0	22.2	30.8	33.3	
8	New Hampshire	26.0	20.0	25.0	28.0	33.0	33.0
19	Pennsylvania	18.9	20.0	21.0	27.5	34.0	37.0
13	Pennsylvania	15.0	22.2	22.2	29.7	33.3	
12	Pennsylvania	15.0	17.5	18.5	22.5	30.0	
17	Pennsylvania	14.4	20.0	21.0	22.5	25.0	
7	New Hampshire	4.9	22.0	25.0	25–30	30–37.5	
6	Maine	4.6	20.0	20.0	20.0	20–25	25.0
2	Massachusetts	1.2	25.0	25.0	25.0	30.0	30.0
Total			327.6	345.1	400.1	456.3	
Average			21.8	23.0	26.7	30.4	
			Southern group				
41	Missouri	740.0	25.0	25.0	25.0	32.5	
37	Louisiana	372.0					
32	Alabama	174.1	15.0	16.5	18.0	22.5	
40	Missouri	84.0	19.0	17.5	18.5	20.0	
34	Florida	62.6					
42	Tennessee	58.6	13.5	13.5	20.0	20.0	
33	Arkansas	55.2	15.0	15.0	20.0	27.5	
43	West Virginia	43.6	17.5	17.5	20.0	25.0	
43	Virginia	38.6	12.2	15.0	20.0	25.0	
35	Kentucky	35.0	20.0	20.0	22.5	25.0	25.0
38	Missouri	33.0	19.5	19.0	20.0	25.0	
36	Kentucky	7.8	20.0	20.0	22.0	22.0	
Total			176.7	179.0	206.0	244.5	
Average			17.7	17.9	20.6	24.5	
Average			21.3	22.1	25.2	28.3	

Unskilled labor costs—information received too late to be included in the original table

REFERENCE NUMBER	GROUP	POPULATION IN THOUSANDS	1914	1915	1916	1917	1918
New York City	Eastern	5,359.					
3	Eastern	16.8	20.7	20.0	25.0	30.0	
10	Eastern	111.0	19.3	17.5	25.9	26.7	
20	Central	289.0	20.0	20.0	22.0	24.0	25.0
34	Southern	68.8	18.0	18.0	18.0	19.0	

TABLE 2

Labor costs in water works pipe extensions, repair work, etc., in the United States. Approximate average cost in cents per hour for skilled and unskilled labor (combined). Found by taking from the pay rolls the total labor cost and dividing it by the man-hours involved Prepared by Leonard Metcalf Feb. 22, 1918.

NOTE. Construction work has been seriously curtailed since 1914 and in most cases could not have been executed at the wage rates here shown, had it been necessary to enlarge the organizations of the works here shown.

LOCATION OF WORKS	POPULATION SERVED (APPROXIMATE)	AVERAGE NUMBER OF MEN (APPROXIMATE)	PRE-WAR CONDITIONS			1915	1916	1917	1918
			1912	1913	1914				
1. Milford, Mass.	16,000	7 to 23	22.6	22.7	21.6	21.0	25.4	30.8	3 mos. only
2. Worcester, Mass. (sewer department) 8 hour day minimum wage here shown for Worcester	160,000	94 to 374	25.0	25.0	25.0	25.0	26.0	29.0	
3. Central N. Y.	100,000	21 to 95	21.5	26.2	24.1	21.3	29.2	31.0	
4. Central Pa.	330,000	26 to 35	20.6	21.5	21.7	21.8	23.6	24.5	
5. Western Pa.	100,000								
6. Central Ind.	275,000	52	20.9	22.0	22.0	22.0	24.5	26.2	27.3
7. Northern Ind.	30,000	17 to 36	24.8	24.8	24.8	24.8	29.2	31.5	38.2
8. Los Angeles	500,000	3700–7800	33.6	34.0	35.6	35.1	36.5	37.7	
Average of seven records above			24.2	25.2	25.0	24.4	27.8	30.3	
Average (of three years)				24.8		98.4%	112.2%	122.2	
9. San Francisco, Cal. Spring Valley Water Co. a In City Distribution Department	450,000	34 to 63 = *Aver.* 45		36.0		34.6	38.5	42.3	Jan. 42.8

b In Service and Meter Department	42 to 88 = 56	41.1	39.3	39.6	42.6	46.7
c In (San Mateo) Water Division	26 to 87 = 51	34.1	37.0	34.2	37.4	41.2
d In Alameda County	24 to 44 = 33	27.4	27.3	26.6	28.5	33.9
Average (a, b, c, d)	Average = 185	35.4	35.5	36.2	39.4	41.7
		100%	100.5%	102.2%	111.2%	118.0%
Common labor		(29.7)	(30.8)	(29.9)	(32.5)	(35.7)
f In Calaveras (Dam)	187 to 478 = 328	28.2	27.5	29.3	30.6	33.6
	Average = 513	31.0	32.0	31.7	34.3	36.9
		100%	103.2%	102.2%	110.7%	119.1%
Treating Calaveras figures as a separate item from the average Spring Valley Water Company figures, we have						
Average (9)		26.6	26.0	28.9	31.2	
		100%	97.8%	108.7%	117.2%	
Spring Valley Water Company		31.0	32.0	31.7	34.3	36.9
		100.0%	103.2%	102.2%	110.7%	119.1%

Conclusion. The average rate paid in cents per hour for skilled and unskilled labor (combined) upon the works here recorded, was in

1915 approximately equal to the rate of 1912–13–14;
1916 approximately 9 per cent above the rate of 1912–13–14;
1917 approximately 17 per cent above the rate of 1912–13–14;

And for the Spring Valley Water Company of San Francisco for

1915 and 1916 approximately 3 per cent above the rate of 1912–13–14;
1917 approximately 11 per cent above the rate of 1912–13–14;
January, 1918, approximately 19 per cent above the rate of 1912–13–14.

Note that these records give no indication of the *decrease in efficiency* which has taken place.

due to the combined effect of loss in wages and loss of efficiency, is approximately 50 per cent in excess of the pre-war costs and nearly as much over those of 1916.

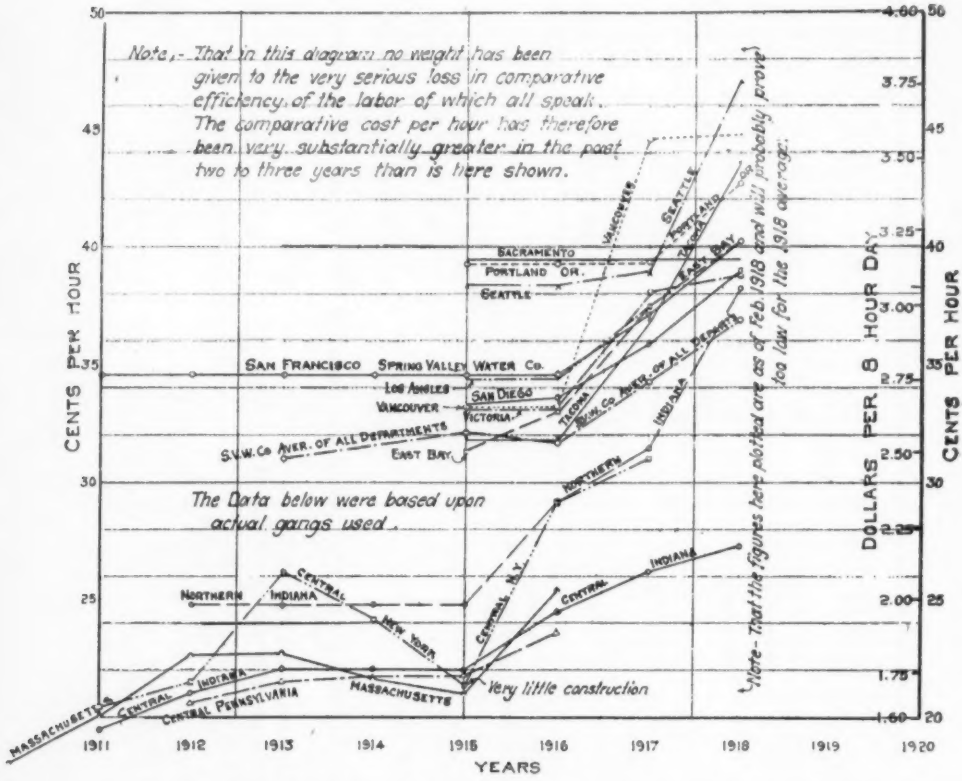


FIG. 2. LABOR COSTS PER MAN-HOUR PAID BY AMERICAN WATER-WORKS, BASED UPON THE ACTUAL AVERAGE COST PER MAN-HOUR OF A GANG OF 50 MEN COMPRISING FOREMAN, SUBFOREMAN, 4 CALKERS, 6 PIPE LAYERS, BLACKSMITH AND 37 LABORERS.

Similar data were gathered by one of the members of this committee at a slightly earlier date, with reference to the advance of labor costs in different parts of this country.

In figure 2, data relating to the central and eastern works were based upon the actual construction gangs used by the works referred

to; the data relating to the western works were based upon the normal gang, or gangs, totalling 50 men. Similar information to that relating to the eastern works was included with reference to the average cost of labor in all departments of the Spring Valley Water Company.

TABLE 3

Increase in cost of water works, cast iron pipe 6 inches and larger

REFERENCE NUMBER	STATE	POPULATION IN THOUSANDS	1914	1915	1916	1917	1918
		Eastern group					
4	Massachusetts	110.0	$22.13	$20.30	$27.10	$38.39	
5	Connecticut	110.0	22.60	21.70	31.00	59.00	$57.00
6	Maine	4.6	24.55†	26.78†			
7	New Hampshire	4.9	21.50†		34.93†		
8	New Hampshire	26.0	24.95	23.86	30.73	32.34	
9	New York	36.9	22.40	21.52	29.50	55.10	54.70
19	Pennsylvania	18.9	24.10	23.10	26.20	44.10	56.25
New York	New York	*	21.20	23.20	31.60	55.40	
Boston	Massachusetts		21.10	17.05	29.15	45.18	
Totals			158.48	150.73	205.28	329.51	167.95
Sub-averages			22.63	21.52	29.35	47.10	
		Central group					
25	Michigan	678.7	23.45	23.45	30.50	30.50	
28	Wisconsin	10.9	25.40	29.30	(†)	59.60	
Chicago	Illinois	..	24.10	24.50	31.80	54.60	
Totals			72.95	77.25	62.30	144.70	
Sub-averages			24.32	25.75	31.15	48.23	
		Southern group					
35	Kentucky	35.0	23.15	22.70	29.70	56.00	
37	Louisiana	372.0	21.00	22.50	22.50	56.00	53.00
41	Missouri	740.0	22.60	22.85	29.95	62.00	
Birmingham	Alabama		18.80	19.00	26.10	48.80	
Totals			85.55	87.05	108.25	222.80	
Sub-averages			21.39	21.76	27.06	55.70	

TABLE 3—*Continued*

REFERENCE NUMBER	STATE	POPULATION IN THOUSANDS	1914	1915	1916	1917	1918
		Western group					
45	California	575.0	30.60	30.59	38.01	62.50	62.20
47	Colorado	213.4	30.00	30.00	36.75	63.75	63.00
51	Oregon	275.7	30.21	29.48	33.95	45.27	63.50
52	Washington	350.0	30.75†				67.50
San Francisco	California		31.30	31.30	36.90	60.20	
Totals			122.11	121.47	145.61	231.72	256.20
Sub-averages			30.53	30.34	36.40	57.93	
Grand totals (18 works)			$439.09	$436.40	$521.44	$928.73	
Average				24.23	30.70	51.60	
Per cent of increase over 1915 costs					26.7	112.9	
		Data received too late to include in above table					
New York	New York‡	5,468.0	$20.45	$22.22	$31.14	$52.48	
3	Massachusetts		22.65	23.55	None bought	None bought	
10	New York		22.04	21.62	27.60	33.58	
20	Indiana		21.65	21.38	25.58	45.88	54.78
34	Florida		22.74	22.28	28.42	51.40	
46	California		31.30	31.30	39.00	57.70	64.10

* Market price given in *Iron Age*.

† Omitted from totals and averages.

‡ Department of Water Supply, Gas and Electricity.

The labor costs involved in maintenance and operation are covered in the discussion upon the increase in cost of operation and maintenance of water works.

Advance in cost of cast iron pipe. The increase in cost of cast iron pipe of 6-inch and larger diameter, reported to the Committee, is indicated in table 3, which shows an increase in prices over those of 1915 of 26.7 per cent in 1916, and 112.9 per cent in 1917. The corresponding figures for 1918 are too fragmentary for averaging, but indicate a slightly smaller increase over 1915 than did the 1917 figures, by reason of the stabilizing effect of governmental control. The difference is nearly negligible, however.

Table 4 shows similar data, obtained by C. C. Cray, purchasing agent of the Indianapolis Water Company, from Chicago, Columbus, Cincinnati, St. Louis, Terre Haute, Evansville, and for New York City and other cities, which were unfortunately received too late for inclusion in the unit figures and averages shown in table 3.

Advance in cost of valves and hydrants. The increase in cost of 6-inch valves to eleven water works, in different parts of the country, is indicated in table 5. It shows an advance in price of 13.1 per

TABLE 4

Prices paid for cast iron pipe in seven cities, f.o.b. destination, tons of 2000 lbs.

	1915		1916		1917		1918	
	Tons	Weighted average cost	Tons	Weighted average cost	Tons	Weighted average cost	Tons	Weighted average cost
Chicago, Ill.	27,765	$21.86	20,681	$27.54	15,255	$34.95		
Columbus, O.	2,606	21.50	950	30.51	1,238	43.23		
Cincinnati, O.	8,500	22.37	4,592	27.71	1,179	41.26		
St. Louis, Mo.	2,626	22.93	1,764	29.95	998	62.00		
Terre Haute, Ind.	47	21.28	357	29.59	37	54.35		
Evansville, Ind.	801	21.00	1,152	25.52	676	38.25		
Weighted average of 6 cities.		21.82		28.47		45.67		
Indianapolis, Ind.	2,150	21.38	1,794	25.58	2,046	45.88	113	$54.78

cent in 1916, 71 per cent in 1917, and approximately 107 per cent in 1918, all as compared with pre-war prices.

Advance in cost of some other water works construction materials. In table 6 are shown data concerning the recent advance in cost of some other water works materials reported by C. C. Cray, purchasing agent of the Indianapolis Water Company; and in table 6a similar data reported by the Spring Valley Water Company of San Francisco.

TABLE 5

Increase in cost of water works valves and hydrants

	1914	1915	1916	1917	THREE MONTHS OF 1918
6-inch valves					
Eastern group (5)					
Massachusetts	$10.50	$10.50	$10.50	$15.00	
Connecticut	10.50	10.50	11.50	20.00	24.28
New York	11.80	11.80	13.00	16.50	
Pennsylvania	11.40	11.40	11.40	16.50	
Pennsylvania	13.85	13.30	13.30	17.75	21.50
Central group (2)					
Michigan	12.35	12.35	14.50	26.50	
Wisconsin	9.20	9.20	14.65	23.06	
Southern group					
Kentucky	12.50	12.50	12.50	16.50	
Missouri	11.40	11.00	12.95	20.60	
Western group					
California	6.714	7.618	10.501	14.01	
Colorado	12.80	12.80	14.20	24.00	
Grand Totals (11)	123.01	122.97	139.00	210.42	45.78[2]
Average (of 11)	11.18	11.18	12.64	19.13	23.20*
Per cent of increase over 1915			13.1	71.1	107.6
12-inch valves					
Connecticut	$31.00	$31.00	$34.50	$62.34	$74.08
Pennsylvania	44.65	36.55	45.10	64.65	60.20
Michigan	36.80	36.80	45.00	69.00	
Grand totals (3)	112.45	104.35	124.60	195.99	134.28[2]
Average (of 3)	37.48	34.78	41.53	65.22	69.00†
Per cent of increase over 1915			19.4	87.6	98.7
2-way hydrants					
1. Connecticut	$33.40	$33.40	$42.70	$54.75	
2. New York	26.70	26.50	28.00	49.78	$60.24
3. Pennsylvania	31.75	31.75	43.50	42.00	54.40
4. Kentucky	24.00	24.00	24.00	35.78	
5. Louisiana	20.00	20.00	21.65	35.10	
6. Missouri	23.75	24.49	26.40	41.40	
Totals (6)	159.60	160.14	186.25	258.81	114.64[3]
Average	26.60	26.69	32.04	43.13	53.90‡
Per cent of increase over 1915			20.1	61.6	102.0

TABLE 5—*Continued*

Data received too late to include in other table

REFERENCE NUMBER	1914	1915	1916	1917	THREE MONTHS OF 1918
6-inch valves					
Boston, Mass.					
New York, N. Y.		$11.30	$13.65	$22.83	
3	$9.00	9.00	13.00	None bought	
10	11.25	11.25	13.88	18.77	
20	21.65	21.38	25.58	45.88	$54.78
34	22.74	22.28	28.42	51.40	
46					
12-inch valves					
Boston, Mass.					
New York, N. Y.			$36.40	$58.33	
3					
10	$31.50	$31.66	33.22		
20	33.00	33.00	39.33	52.50	$63.00
34					
46					
2-way hydrants					
Boston, Mass.					
New York, N. Y.		$24.77	$31.15	$45.75	
3	$28.10	28.27	28.80	None bought	
10					
20	34.00	33.50	39.44	54.77	
34	32.00		28.10	51.40	
46					

Note:—For 1918, the average prices shown are for the first two or three months of the year only and are found by multiplying the 1917 average by the ratio of the sum of the items in 1918 to the sum of the corresponding items in 1917.

* Average of two items is $22.89.

† Average of two items is $67.14.

‡ Average of two items is $57.32.

TABLE 6

Weighted average cost of construction materials to the Indianapolis Water Company for 1915, 1916, 1917 and three months of 1918, and percentage increase over 1915 prices

ITEM	UNIT	1915	1916	1917	1918 THREE MONTHS	INCREASED 1917 OR 1918 OVER 1915
						per cent
1. Cast iron pipe	Ton	$21.38	$25.58	$45.88	$54.78	156
2. Cast iron fittings	100 lbs.	2.502	2.75	4.19		67
3. Pig lead	100 lbs.	4.469	6.555	10.77		141
4. Jute	100 lbs.	6.50	7.75	10.50		61
5. Valves, 6-inch	Each	11.25	13.88	18.77		67
12-inch	Each	33.00	39.33	52.50	63.00	91
6. Valve boxes	Each	1.60	2.03	2.35	2.72	70
7. Hydrants—2-way and steamer	Each	33.50	39.44	54.77		63
8. Corporation cocks, ½-inch	Each	0.32		0.713	0.84	162
9. Stop boxes, 3-inch	Each	0.63	0.75	0.91	1.27	101
10. Brick, common	1000	8.00	8.50	10.50	13.00	62
11. Paving, common	1000	35.00				
12. Cement, Sacks inc	Barrel	1.80	1.959	2.207	3.00	66
13. ⅝-inch meters	Each	6.99	8.40*	9.86	10.50†	50
14. ¾-inch meters	Each	10.50		14.83		
15. 1-inch meter	Each	14.00		19.50		
16. 2-inch meters	Each	41.65		62.36	62.50†	
17. 3-inch meters	Each	70.80		85.00		
18. Lumber Y. P	M	26.00	33.00	37.50	44.00	69
19. Sand and gravel	Load					
20. Reinforcing steel	100 lbs.	2.55	3.15	3.50	4.00	57

* Few purchases.

† Quotations.

TABLE 6 a

Prices paid by the Spring Valley Water Company, San Francisco

MATERIAL	PRICE NORMAL	PRICE JANUARY, 1918	PERCENTAGE OF INCREASE	TOTAL PERCENTAGE OF INCREASE. WEIGHTED AVERAGE
Oil, fuel, per barrel	$0.70½	$1.45	106.0	
Oil, cylinder, per gallon	.53	.86	36.5	
Packing, flax, per pound	.40	.81	102.5	99.5
Tubes, boiler, per foot	.32	.84	162.0	
Valves, rubber, per pound	.70	.90	28.5	
Waste, cotton, per pound	.09	.15	66.5	
Oil, dynamo, per gallon	.36	.531	47.5	
Waste, cotton, per pound	.09	.15	66.5	50.0
Polish, metal, per gallon	.85	.90	6.0	
Cheese cloth, per yard	.03¾	.10½	180.0	180.0
Hay, per ton	18.00	30.00	66.5	66.5
Copper sulphate, per hundredweight	5.50	10.75	95.5	95.5
Paint, per gallon	.65	1.10	69.5	69.5
Hay, per ton	18.00	30.00	66.5	66.5
Asphaltum, per ton	12.50	17.60	40.0	
Coal tar, per barrel	6.00	12.00	100.0	
Oakum, per bale	4.50	8.75	94.5	74.0
Lumber, base	12.50	24.00	92.0	
Nails, per hundredweight	2.35	4.70	100.0	
Paint, per gallon	.65	1.10	69.5	
Paint, per gallon	.65	1.10	69.5	
Lumber, base	12.50	24.00	92.0	85.0
Nails, per hundredweight	2.35	4.70	100.0	
Paint, per gallon	0.65	1.10	69.5	69.5
Meter parts			20.0	
Fittings, brass, per pound	.35	.57½	64.5	
Fittings, galvanized	List less 85%	List less 65 and 10%	110.0	60.0
Covers, meters, per pound	.03½	.06¼	78.5	
Leather, per pound	.40	.70	75.0	
Picks, per dozen	6.50	12.75	96.0	

TABLE 6 a—*Concluded*

MATERIAL	PRICE NORMAL	PRICE JANUARY, 1918	PERCENTAGE OF INCREASE	TOTAL PERCENTAGE OF INCREASE, WEIGHTED AVERAGE
Shovels, per dozen	11.00	18.50	68.0	
Cutters, pipe, each	1.50	2.75	83.5	60.0
Stocks and dies, each	5.00	8.00	60.0	
Wrenches, each	.75	1.50	100.0	
Pipe, cast iron, per ton	35.00	62.00	76.5	
Fittings, cast iron, per pound	.03½	.06¼	78.5	
Lead, pig, per pound	.04¼	.07	65.0	
Jute, per pound	.06	.12	100.0	70.0
Coal, per ton	10.00	13.00	30.0	
Picks, per dozen	6.50	12.75	96.0	
Shovels, per dozen	11.00	18.60	68.0	
Bars, crow, per pound	.04	.10	150.0	
Fittings, brass, per pound	.35	.56½	64.5	
Fittings, galvanized	List less 85%	List less 65 and 10%	110.0	
Pipe, galvanized, per cubic foot	4.50	10.05	124.0	
Pipe, lead, per hundredweight	6.50	10.75	65.5	
Picks, per dozen	6.50	12.75	96.0	87.5
Shovels, per dozen	11.00	18.50	68.0	
Cutters, pipe, each	1.50	2.75	83.5	
Stocks and dies, each	5.00	8.00	60.0	
Wrenches, each	.75	1.50	100.0	
Leather, per pound	.40	.70	75.0	
Office furniture			40.0	
Stationery			50.0	40.0
Printing			33.0	
Office furniture			40.0	
Stationery			50.0	
Printing			33.0	50.0
Hardware, builders'			50.0	
Shellac, per gallon	1.28	3.20	150.0	
Janitor's supplies			50.0	
Lumber, per base	12.50	24.00	92.0	
Nails, per hundredweight	2.35	4.70	100.0	80.0
Fencing, per hundredweight	2.65	5.55	109.5	
Paint, per gallon	.65	1.10	69.5	

ADVANCE IN COST OF OPERATING SUPPLIES

Turning now to important typical operating supplies, such as coal and alum, yet greater increase in price has taken place.

Coal. The prices paid for coal by 41 important water works, table 7, indicate an advance in prices in 1916, 1917 and early 1918, over those prevailing in 1915, of approximately 15, 74 and 117 per cent, respectively. It is interesting to note the variation in the different parts of the country. The East suffered in far greater measure than the South and the West; the Central States in like measure with the Southern and Western states in the years 1916

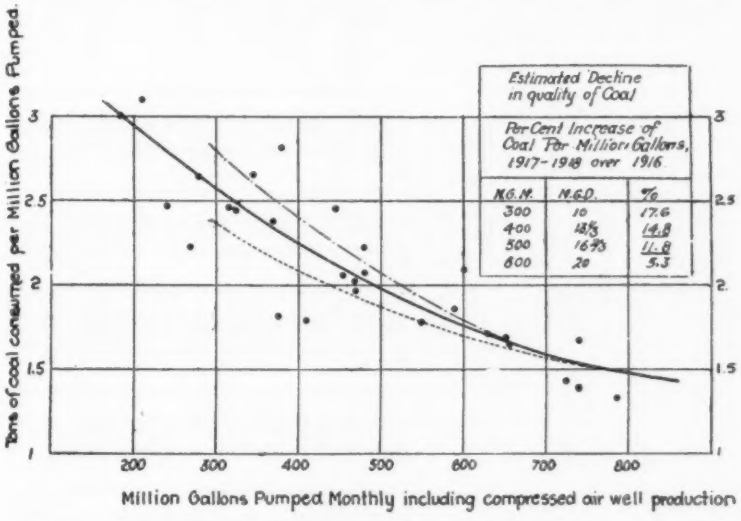


FIG. 3. PUMPAGE AND COAL FOR 28 MONTHS ENDING APRIL 30, 1918

and 1917, and in greater measure than any of the other groups in 1918. Incidentally, it may also be noted that the prices of fuel oil reported for one large plant in Louisiana and one in California show an advance in price in the opening of 1918 of approximately 150 per cent over those prevailing in 1915.

Unfortunately, in coal as in labor, the advance in unit prices does not reflect the entire increase in cost, inasmuch as decline in quality of the coal has been very generally observed. Effort was recently made to obtain exact information upon this subject by the Indianapolis Water Company through a study of the relative coal consumption per million gallons of water pumped during the past two years, or thereabouts. The results of this study, shown in figure 3,

TABLE 7

Increase in cost of water works fuel

REF. NO.	STATE	POPULATION IN THOUSANDS	COAL, DOLLARS PER TON					
			1914	1915	1916	1917	1918	
			Eastern group					
2	Massachusetts	1.2	$5.56	$5.56	$6.71	$11.21		
4	Massachusetts	110.0	4.18	4.20	5.33	10.00		
6	Maine	4.6	4.90	4.72	6.12	10.84	$12.00	
7	New Hampshire	4.9	4.38	4.39	5.04	8.05		
8	New Hampshire	26.0	4.80	4.90	6.75	9.00	9.00	
9	New York	36.9	3.45	3.45	3.85	6.48	7.65	
11	Pennsylvania	26.6	2.61	2.56	2.99	3.40		
12	Pennsylvania	15.0	1.21	1.24	1.68	2.55		
13	Pennsylvania	15.0	1.59	1.20	1.40	2.87		
14	Pennsylvania	40.4	1.27	1.45	2.84	3.67		
16	Pennsylvania	150.0	1.90	1.77	2.14	3.45		
17	Pennsylvania	14.4	1.82	2.08	3.33	4.33		
19	Pennsylvania	18.9	1.23	1.28	1.17	1.58	4.33	
Totals			38.90	38.80	49.35	77.43	32.98	Average of four items is $8.24
Sub-average of eastern group			2.99	2.98	3.80	5.96	7.04	

Central group

21	Indiana	20.3	2.02	1.91	1.96	2.55		
22	Indiana	5.6	1.21	1.11	1.77	2.87		
23	Indiana	5.6	1.25	1.25	1.86	3.13		
24	Indiana	25.2	1.83	1.94	2.16	2.90		
25	Michigan	678.7	2.29	2.21	2.37			
26	Illinois	72.1	1.34	1.49	1.88	2.67		
27	Ohio	4.0	5.40	5.32	5.40	5.34		
28	Wisconsin	10.9	2.89	2.87	2.67	3.85	6.55	
29	Wisconsin	14.6	2.32	2.18	2.73	4.82		
30	Wisconsin	8.8	3.52	3.51	4.53	5.45		
31	Wisconsin	45.5	2.75	2.72	3.17	4.45		
Totals			26.82	26.51	30.50	38.03	6.55	Average of one item is $6.55
Sub-average			2.44	2.41	2.77	3.75	6.38	

* Mine run screenings.

TABLE 7—*Continued*

REF. NO.	STATE	POPULATION IN THOUSANDS	COAL, DOLLARS PER TON					
			1914	1915	1916	1917	1918	
			Southern group					
32	Alabama	174.1	1.29	1.29	1.20	1.64		
33	Arkansas	55.2	2.33	2.31	2.46	3.34		
35	Kentucky	35.0	* 1.75	1.75	1.75	1.90	3.00	
			0.90	0.90	0.90	1.00	1.50	
36	Kentucky	7.8	1.88	2.55	2.61	4.52		
37	Louisiana	372.0	2.57	2.65	2.56	3.81	4.40	
38	Missouri	33.0	2.14	2.08	2.50	3.52		
39	Missouri	4.5	2.02	1.91	1.96	2.82		
40	Missouri	84.0	2.06	1.75	2.07	3.30		
41	Missouri	740.0	1.59	1.56	1.60	2.96		
42	Tennessee	58.6	1.69	1.64	1.92	3.39		
43	Virginia	38.6	2.99	2.85	2.92	5.30		
44	West Virginia	43.6	1.79	1.79	1.66	1.95		
Totals			25.00	25.03	26.11	39.45	8.90	Average of three items is $2.97
Sub-average			1.92	1.92	2.01	3.03	4.02	
			Western group					
45	California	575.0	9.50	9.50	9.50	16.50		
47	Colorado	213.4	4.05	4.05	4.60	5.00	6.25	
48	Iowa	27.1	1.87	1.95	2.61	3.73		
49	Iowa	14.0	1.85	1.90	2.00	2.55		
50	Kansas	67.8	2.50	2.44	3.16	3.76		
Totals			19.77	19.84	21.87	31.54	6.25	Average of one item is $6.25
Sub-average			3.95	3.97	4.37	6.31	7.89	

Average of all four group sub-averages

			DOLLARS PER TON					PER CENT OF INCREASE OVER 1915 COSTS		
								1916	1917	1918
Eastern group			2.99	2.98	3.80	5.96	7.04	27.5	100.0	138.3
Central group			2.44	2.41	2.77	3.75	6.38	14.9	56.4	164.7
Southern group			1.92	1.92	2.01	3.03	4.02	4.7	57.8	109.4
Western group			3.95	3.97	4.37	6.31	7.89	10.1	58.9	98.7
Average of group averages			2.82	2.82	3.24	4.77	6.33	14.9	69.2	124.4
Average of 41 works			2.63	2.62	3.04	4.52	5.69	15.3	73.7	117.1
Fuel oil, cents per gallon										
37	Louisiana	372.0	2.7	1.80	1.80	2.00	4.50	0.0	11.1	150.0
45	California	575.0	1.785	1.38	1.50	2.57	3.55	8.7	86.2	157.3

* Mine run screenings

NOTE. For 1918, the average prices shown are for the first two or three months of the year only and are found by multiplying the 1917 average by the ratio of the sum of the items in 1918 to the sum of the corresponding items in 1917.

TABLE 7—*Concluded*

Data received too late to include in table

REF. NO.	STATE	POPULATION IN THOUSANDS	COAL, DOLLARS PER TON					
			1914	1915	1916	1917	3 months of 1918	
	Boston, Mass.							
	New York, N. Y.		2.93	2.86	3.55	6.06		
3								
10								
20				1.45	1.496	2.439	3.323	
34								
46								
	Fuel oil, cents per gallon							
20				7.0	8.0	10.0	12.0	

TABLE 8

Increase in cost of alum

REFERENCE NUMBER	STATE	1914	1915	1916	1917	1918
	Eastern group					
		cts.	*cts.*	*cts.*	*cts.*	*cts.*
6	Maine	1.33	1.78	3.37	2.30	2.33
7	New Hampshire	1.17	1.65	3.38	2.14	
11	Pennsylvania	0.985	0.985	0.985	1.345	
12	Pennsylvania	0.905	0.905	0.905	1.26*	
13	Pennsylvania	1.06	1.06	1.06	1.345	
14	Pennsylvania	0.87	0.87	0.87	1.225	
16	Pennsylvania	0.935	0.935	0.935	1.295	
17	Pennsylvania	0.96	0.96	0.96	1.245	
19	Pennsylvania	1.025	1.0	3.0	1.17†	1.30
	Central group					
22	Indiana	0.96	0.96	0.96	1.28	
24	Indiana	0.93	0.93	0.93	1.28	
26	Illinois	0.91	0.91	0.91	1.216	
29	Wisconsin	0.92	0.92	0.92	1.255	
30	Wisconsin	0.87	0.87	0.87	1.205	
	Southern group					
32	Alabama	1.20	1.20	1.20	1.50	
33	Arkansas	1.19	1.19	1.19	1.49	
35	Kentucky	0.575	0.575	1.12	1.100	
36	Kentucky	1.22	1.25	3.75	2.26	
38	Missouri	1.135	1.135	1.135	1.435	
39	Missouri	0.97	0.97	0.97	1.276	
40	Missouri	0.975	0.975	0.975	1.275	
41	Missouri	0.923§	0.923	1.136	1.271	
42	Tennessee	1.25	1.25	1.25	1.56	
43	Virginia	1.07	1.07	1.07	1.47	
44	West Virginia	0.935	0.935	0.935	1.26	
	Western group					
47	Colorado	1.30	1.30	1.45	1.75	1.75 (3 mos.)
49	Iowa	0.97	0.97	0.97	1.276	

TABLE 8—*Concluded*

REFERENCE NUMBER	STATE	1914	1915	1916	1917	PER CENT INCREASE OF COST OVER 1915	
						1916	1917
	Averages by groups						
	Eastern (9).....	1.027	1.116	1.718	1.481	54.0	32.7
	Central (5).....	0.91	0.91	0.91	1.247	0.0	37.0
	Southern (9).....	1.074	1.078	1.379	1.477	28.0	37.0
	Western (2).....	1.14	1.14	1.21	1.513	6.1	41.4
	Average of group averages.....	1.038	1.058	1.304	1.429	23.3	35.1
	Average of 25 works..	1.031	1.068	1.395	1.435	30.6	34.4
20	Indiana		0.861	0.936	1.479		
	New York market price	1.55	2.08	4.63	3.57	123.0	71.6

In using these data, the effect of old contracts carrying over this period is to be remembered. The relation between the prices paid and the current market prices are indicated in the above tabulation.

indicate a decline in quality of the coal of from 10 to 15 per cent, broadly speaking. The results are characteristic, rather than precise.

Carleton E. Davis, chief of the Bureau of Water of Philadelphia, reports that at one of their main pumping stations the increase in coal consumption during the past twelve months or so was 17.3 per cent per million gallons pumped, because of the inferior quality of the coal. At other stations a change in the type of pump or character of fuel used makes a comparison impossible.

Advance in price of alum. The record of prices paid by water works for alum, in cents per pound, is interesting and significant. It is to be borne in mind, however, that it reflects the leveling effect of long-time contracts under a rising market. This is indicated by comparison (table 8) of the prices submitted, with the average New York market prices, quoted from the *Journal of Industrial and Engineering Chemistry.*

The figures submitted indicate an advance in 1916 and 1917 over the prices of 1915, of approximately 30 and 34 per cent, whereas the advance in the New York market prices over the 1915 scale,

was 123 per cent in 1916, and approximately 72 per cent in 1917, the decline in the latter reflecting governmental control.

Some other operation supplies. Table 9 shows prices for sundry operating and maintenance supplies paid by the Indianapolis Water

TABLE 9

Prices paid for supplies used in operation and maintenance by the Indianapolis Water Company in 1915, 1916, 1917 and three months of 1918

ITEM	UNIT	1915	1916	1917	1918 QUOTATIONS	INCREASE OVER 1915
						per cent
1. Coal	Ton	$1.45	$1.496	$2.439	$3.323	129
2. Alum	100 lbs.	.861	.936	1.479	1.939	125
3. Chlorine gas	100 lbs.		12.50	12.50	15.00	20
4. Oil, engine	Gallon	.179	.195	.25	.35	95
5. Oil, H. P. cylinder	Gallon	.349	.35	.44	.555	59
6. Oil, L. P. cylinder	Gallon	.234	.25	.34	.555	137
7. Oil, linseed oil	Gallon	0.84	0.78	0.97	1.50	78
8. White lead	100 lbs.	7.50	9.80	11.50	12.25	63
9. Electric power	K.W.H.	.01	.01	.015	.015	50*
		.0125	.0125	.0175	.0175	40*
10. Brass castings	Pound	.22	.35	.45	.50	127
11. Special cast iron casting	Pound	.0292	.0325	.0411	.0522	78
12. Steel boiler tubes 4 inches	Foot	.1675	.2285	.55	.60	258
13. Printing bills	1000	.76	1.23	1.42	1.91	151
14. Heat (M. H. Lt. Co.)	Year	*Cont.*	*Cont.*	25%	Increase	25*
15. Rags (instead of waste)	Pound	.05	.06	.07	.08	60
16. Gasoline	Gallon	.125	.175	.215	.25	100
17. Coal oil	Gallon	.07	.08	.10	.12	71

* Exclusive of demand charges.

Company, during 1915, 1916, 1917 and 1918, furnished by C. C. Cray, purchasing agent of the company.

Summary. In table 10 and figures 4 and 5 are summarized the increases in cost of labor and materials, already referred to.

TABLE 10

Summary of data upon increase in cost of labor and materials to water works in the United States is reported to the Executive Committee of the American Water Works Association, May, 1918

ITEM NO.	ITEM	NUMBER OF RECORDS	PRICES PER UNIT				INCREASE OVER 1915		
			1915	1916	1917	3 months 1918	1916	1917	3 months 1918
			cts.	*cts.*	*cts.*		*per cent*	*per cent*	*per cent*
1	Unskilled labor*—in cents per hour								
	a. Western group	7	27.0	28.5	31.4	Still increasing in all groups	5	16	Still increasing in all groups
	b. Central group	12	21.7	25.3	26.9		17	24	
	c. Eastern group	15	23.0	26.7	30.4		16	32	
	d. Southern group	10	17.9	20.6	24.5		15	37	
	e. Average of groups (4)	—	22.4	25.3	28.3		13	27	
	f. Average of all	44	22.1	25.2	28.3		14	28	
2	Cast iron pipe—per 2000 lbs	21	$24.23	$30.70	$51.60		26.7	112.9	
3	6-inch valves	11	$11.18	$12.64	$19.13	$23.20	13.1	71.1	107.6
4	12-inch valves	3	34.78	41.53	65.22	69.00	19.4	87.6	98.7
5	2 way hydrants	6	$26.69	$32.04	$43.13	$53.90	$20.1	$61.6	$102.0
6	Coal per 2000 lbs.								
	a. Eastern group	13	$2.98	$3.80	$5.96	$7.04	27.5	100	136.3
	b. Central group	11	2.41	2.77	3.75	6.38	14.9	56.4	164.7
	c. Southern group	12	1.92	2.01	3.03	4.02	4.7	57.8	109.4
	d. Western group	5	3.97	4.37	6.31	7.89	10.1	58.9	98.7
	e. Average of groups (4)		2.82	3.24	4.77	6.33	14.9	69.2	124.4
	f. Average of all	41	$2.62	$3.04	$4.52	$5.69	15.3	73.7	117.1

			cts.	cts.	cts.	cts.			
7	Fuel oil, cents per gallon.....	1	$1.80	1.80	2.00	4.50	0.0	11.1	150.0
	Fuel oil, cents per gallon.....	1	1.38	1.50	2.57	3.55	8.7	86.2	157.3
			cts.	cts.	cts.	cts.			
8	Alum, cents per pound								
	a. Western group.....	2	1.14	1.21	1.51		6.1	41.4	
	b. Central group.....	5	0.91	0.91	1.25		0.0	37.0	
	c. Eastern group.....	9	1.12	1.72	1.48		54.0	32.7	
	d. Southern group.....	9	1.08	1.38	1.48		28.0	37.0	
	e. Average of groups (4).....		1.06	1.30	1.43		23.3	35.1	
	f. Average of all.....	25	1.07	1.40	1.44		30.6	34.4	
	g. New York market price†.....	‡	2.08	4.63	3.57	5 mos 3.15	123.0	71.6	51.4

* NOTE. It was generally reported that there has been also a marked decrease in efficiency of labor since the year 1914, variously estimated at between 20 per cent and 50 per cent; and that the increase in wages paid to labor by Water Work had not kept pace with contract prices owing probably to the advantage of continuity of service.

† *See Journal of Industrial and Engineering Chemistry.* Note that 1915 price was an advance of 34 per cent over the 1914 average price before the advances listed went into effect.

‡ Average of monthly prices.

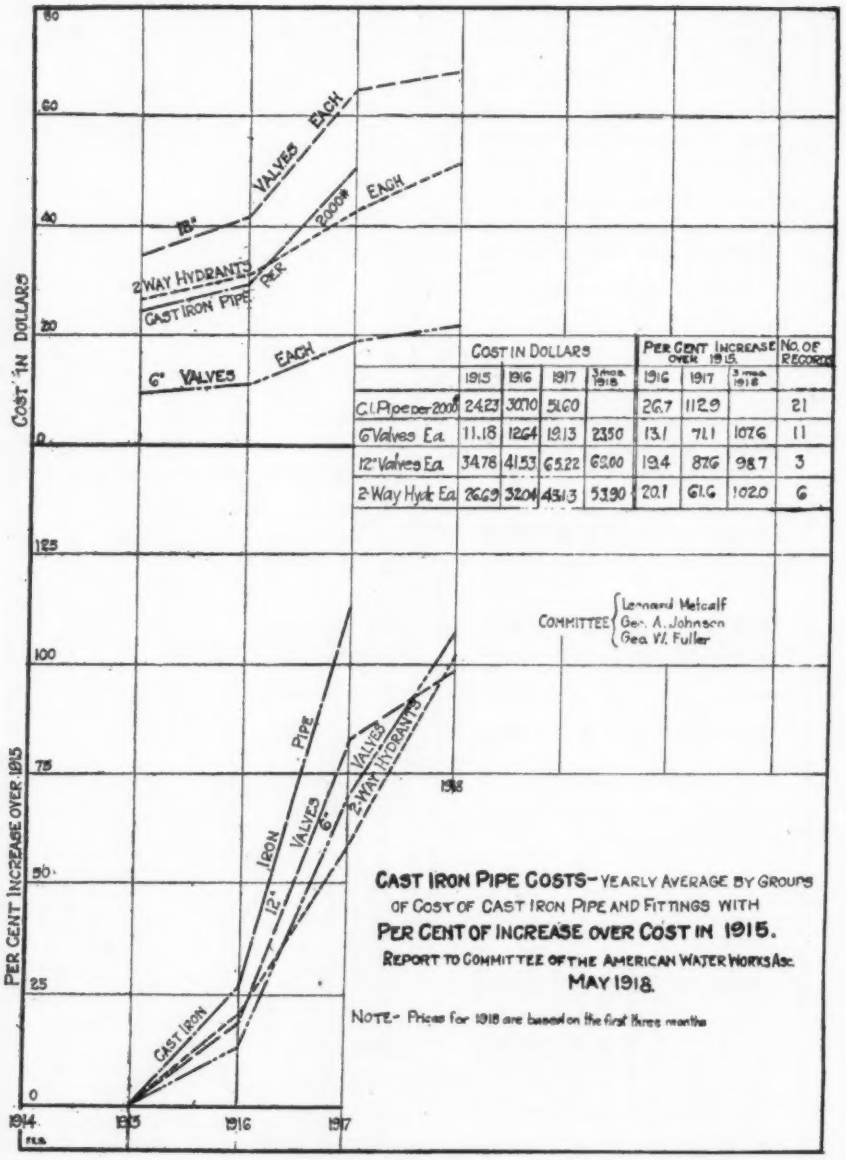
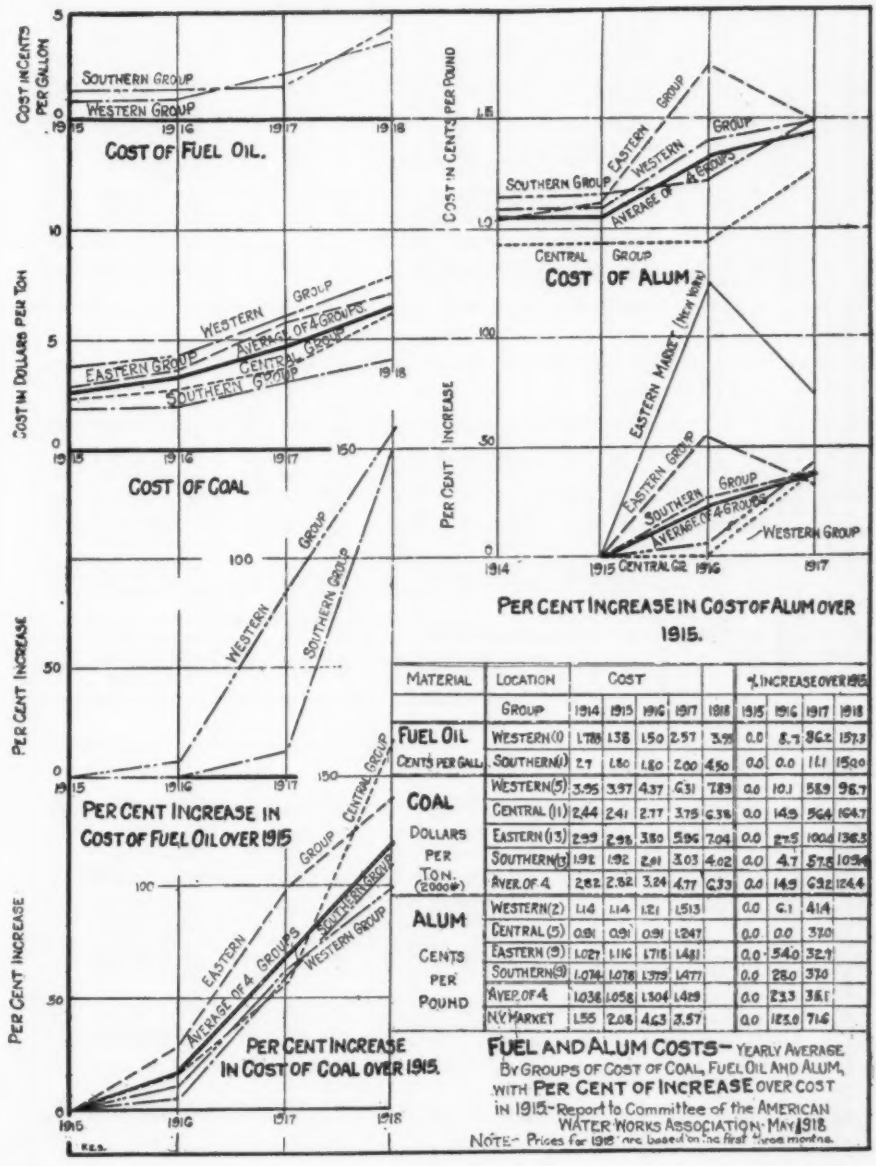

COST IN DOLLARS
PER CENT INCREASE OVER 1915
12" VALVES EACH
2 WAY HYDRANTS
CAST IRON PIPE PER 2000# EACH
6" VALVES EACH
COST IN DOLLARS
1915 1916 1917 3 mos. 1918
C.I. Pipe per 2000# 24.23 30.10 51.60
6" Valves Ea. 11.18 12.64 19.13 23.50
12" Valves Ea. 34.78 41.53 65.22 69.00
2-Way Hyd. Ea. 26.69 32.04 45.13 53.90
PER CENT INCREASE OVER 1915
1916 1917 3 mos. 1918 NO. OF RECORDS
26.7 112.9 21
13.1 71.1 107.6 11
19.4 87.6 98.7 3
20.1 61.6 102.0 6
COMMITTEE Leonard Metcalf, Geo. A. Johnson, Geo. W. Fuller
CAST IRON PIPE
12" VALVES
6" VALVES
2-WAY HYDRANTS
CAST IRON PIPE COSTS - YEARLY AVERAGE BY GROUPS OF COST OF CAST IRON PIPE AND FITTINGS WITH PER CENT OF INCREASE OVER COST IN 1915.
REPORT TO COMMITTEE OF THE AMERICAN WATER WORKS ASS'N.
MAY 1918.
NOTE - Prices for 1918 are based on the first three months
1914 1915 1916 1917 1918

FIGURE 4


COST IN CENTS PER GALLON
SOUTHERN GROUP
WESTERN GROUP
COST OF FUEL OIL.
COST IN DOLLARS PER TON
EASTERN GROUP
WESTERN GROUP
AVERAGE OF 4 GROUPS
CENTRAL GROUP
SOUTHERN GROUP
COST OF COAL
PER CENT INCREASE
PER CENT INCREASE IN COST OF FUEL OIL OVER 1915
PER CENT INCREASE IN COST OF COAL OVER 1915.
COST IN CENTS PER POUND
CENTRAL GROUP
COST OF ALUM.
EASTERN MARKET (NEW YORK)
PER CENT INCREASE IN COST OF ALUM OVER 1915.

MATERIAL	LOCATION GROUP	COST 1914	1915	1916	1917	1918	% INCREASE OVER 1915 1915	1916	1917	1918
FUEL OIL	WESTERN (1)	1.788	1.38	1.50	2.57	3.95	0.0	8.7	86.2	197.3
CENTS PER GALL.	SOUTHERN (1)	2.7	1.80	1.80	2.00	4.50	0.0	0.0	11.1	150.0
COAL	WESTERN (5)	3.95	3.97	4.37	6.31	7.89	0.0	10.1	58.9	98.7
DOLLARS PER TON. (2000#)	CENTRAL (11)	2.44	2.41	2.77	3.75	6.38	0.0	14.9	56.4	164.7
	EASTERN (13)	2.99	2.98	3.80	5.96	7.04	0.0	27.5	100.0	136.5
	SOUTHERN (3)	1.92	1.92	2.01	3.03	4.02	0.0	4.7	57.8	109.4
	AVER. OF 4.	2.82	2.82	3.24	4.77	6.33	0.0	14.9	69.2	124.4
ALUM	WESTERN (2)	1.14	1.14	1.21	1.513		0.0	6.1	41.4	
CENTS PER POUND	CENTRAL (5)	0.91	0.91	0.91	1.247		0.0	0.0	37.0	
	EASTERN (9)	1.027	1.116	1.178	1.481		0.0	5.4.0	32.7	
	SOUTHERN (9)	1.074	1.078	1.379	1.477		0.0	28.0	37.0	
	AVER. OF 4.	1.038	1.058	1.304	1.429		0.0	23.3	35.1	
	N.Y. MARKET	1.55	2.08	4.63	3.57		0.0	123.0	71.6	

FUEL AND ALUM COSTS— YEARLY AVERAGE BY GROUPS OF COST OF COAL, FUEL OIL AND ALUM, WITH **PER CENT OF INCREASE** OVER COST IN 1915.— Report to Committee of the AMERICAN WATER WORKS ASSOCIATION. MAY 1918.

NOTE— Prices for 1918 are based on the first three months.

FIGURE 5

TABLE 11

Percentage of revenue and operating expenses of values for year 1915 for water works companies in the United States

REFERENCE NO.	STATE	GROSS ANNUAL REVENUE IN PER CENT OF 1915						OPERATING EXPENSES AND TAXES EXCLUDING DEPRECIATION IN PER CENT OF 1915						OPERATING REVENUE APPLICABLE TO DEPRECIATION, INTEREST, DIVIDEND AND SURPLUS IN PER CENT OF 1915					
		1913	1914	1915	1916	1917	Fraction of 1918	1913	1914	1915	1916	1917	Fraction of 1918	1913	1914	1915	1916	1917	Fraction of 1918
	Western group																		
45	California		102.3	100	126.0	115.5				100	125.6	120.5				100	126.3	113.5	
46	California		94.3	100	100.2	105.7			93.4	100	102.5	103.5	113.6		94.9	100	98.4	106.8	
47	Colorado		98.4	100	100.8	104.1			102.7	100	101.1	101.2			74.9	100	99.3	115.8	
48	Iowa		103.9	100	109.2	114.3			98.9	100	112.2	117.1			108.2	100	106.5	111.8	
49	Iowa		98.1	100	107.3	106.3			97.3	100	112.2	140.2			98.3	100	98.4	86.1	
50	Kansas		99.6	100	108.8	114.9			99.8	100	111.5	149.6			99.5	100	107.4	96.6	
51	Oregon		118.9	100	106.2	100.3			108.3	100	106.1	109.4			142.3	100	106.5	75.5	
52	Washington		98.1	100	100.2	115.0			89.9	100	198.6	97.6			107.7	100	90.5	135.9	
	Total.....		813.6	800	858.8	876.1			690.3	800	879.8	939.1			725.8	800	833.3	842.0	
	Average of group.....		101.7	100	107.3	109.5			98.6	100	109.9	117.4	113.6		103.6	100	104.3	105.3	
	Average of records.....		98.9	100	106.1	108.0			99.5*	100	106.5	105.8			94.5	100	105.8	110.3	
	Central group																		
20	Indiana		96.1	100	108.0	108.0	107.0		96.1	100	135.8	154.1	154.9		96.2	100	96.6	89.6	
21	Indiana		92.9	100	111.4	114.8			102.3	100	122.6	144.3			88.0	100	105.8	100.2	
22	Indiana		97.6	100	101.1	91.0			104.3	100	121.0	123.8			93.2	100	87.2	68.1	
24	Indiana		99.8	100	106.2	114.1			102.8	100	130.0	148.9			96.9	100	94.0	96.6	
25	Michigan																		
26	Illinois		100.6	100	112.3	117.9			90.6	100	114.9	132.1			107.5	100	110.6	108.4	

27	Ohio		80.7	100	126.1	131.0			88.6	100	128.0	157.5			61.0	100	122.1	65.7	
28	Wisconsin		101.7	100	105.5	120.4			96.3	100	102.2	130.5			109.3	100	110.5	111.5	
39	Wisconsin		96.1	100	101.6	101.3			99.2	100	114.2	133.4			94.2	100	92.8	77.8	
30	Wisconsin		94.1	100	112.0	111.3			121.0	100	124.0	135.0			63.5	100	99.4	84.6	
31	Wisconsin		97.6	100	116.3	118.2			95.9	100	126.1	151.0			99.0	100	111.1	101.8	
	Total		957.2	1000	1100.5	1128.0	107.0		997.1	1000	1218.9	1410.6			908.8	1000	1030.1	904.5	
	Average of group		95.7	100	110.1	112.8	107.0		99.7	100	121.9	141.1	154.9		90.9	100	103.0	90.6	
	Average of records		97.6	100	109.8	116.7			95.6	100	125.0	144.1			98.6	100	97.7	94.2	
	Eastern group																		
1	Massachusetts		101.6	100	105.5	100.3			100.7	100	103.5	119.2			102.0	100	106.5	90.4	
2	Massachusetts		95.3	100	106.0	102.4			101.2	100	99.1	114.1			90.2	100	111.4	92.2	
3	Massachusetts		97.2	100	100.4	100.8			114.8	100	113.0	129.6			84.7	100	91.9	80.7	
4	Massachusetts		94.5	100	108.1	105.8			96.8	100	123.1	139.0			91.4	100	87.6	84.9	
5	Connecticut	95.2	99.5	100	110.6	121.5		88.6	108.3	100	103.3	147.3		100.3	92.7	100	116.3	101.8	
6	Maine		109.6	100	114.6	126.3			101.8	100	102.1	119.6			128.8	100	145.1	143.1	
7	New Hampshire		98.9	100	102.8	105.6			85.6	100	114.4	118.5			110.0	100	93.2	94.8	
8	New Hampshire		100.0	100	102.2	106.2	109.8		100.2	100	90.8	101.8	114.1		99.8	100	111.7	110.3	105.9
9	New York		102.3	100	110.6	119.2	120.8		105.2	100	85.8	111.2	125.3		99.3	100	135.8	127.0	116.1
10	New York		98.1	100	108.7	114.9			110.2	100	100.0	117.6			94.3	100	111.5	114.0	
11	Pennsylvania		97.5	100	116.6	111.3			101.8	100	140.1	181.5			95.8	100	106.9	86.3	
12	Pennsylvania		103.8	100	110.6	114.2			103.3	100	117.9	170.6			102.0	100	105.6	81.2	
13	Pennsylvania		96.2	100	108.5	117.3			106.1	100	99.0	151.5			89.1	100	115.9	92.4	
14	Pennsylvania		93.1	100	120.0	109.0			89.2	100	124.4	177.1			95.6	100	117.4	67.7	
15	Pennsylvania																		
16	Pennsylvania		94.3	100	113.7	119.8			92.3	100	116.8	161.5			95.2	100	112.1	98.0	
17	Pennsylvania		102.2	100	101.1	109.5			104.6	100	127.8	183.6			101.3	100	90.6	80.0	

TABLE 11—*Concluded*

REFERENCE NO.	STATE	GROSS ANNUAL REVENUE IN PER CENT OF 1915						OPERATING EXPENSES AND TAXES EXCLUDING DEPRECIATION IN PER CENT OF 1915						OPERATING REVENUE APPLICABLE TO DEPRECIATION, INTEREST, DIVIDEND AND SURPLUS IN PER CENT OF 1915					
		1913	1914	1915	1916	1917	Fraction of 1918	1913	1914	1915	1916	1917	Fraction of 1918	1913	1914	1915	1916	1917	Fraction of 1918
	Eastern group—continued																		
18	Pennsylvania		98.2	100	105.0	105.9			92.4	100	101.1	98.7			100.0	100	106.3	108.0	
19	Pennsylvania		85.1	100	111.2	124.3	129.6		103.1	100	104.1	131.5	181.0		89.1	100	115.6	119.6	97.2
	Total		1767.4	1800	1965.2	2014.3			1817.6	1800	1966.3	2473.1			1761.3	1800	1981.0	1772.4	
	Average of group		98.3	100	109.1	111.4			100.9	100	109.3	137.3			97.3	100	110.0	98.5	
	Average of records		97.8	100	105.0	105.5			100.8	100	95.9	112.7			96.5	100	105.7	95.8	
	Southern group																		
32	Alabama		106.7	100	111.8	125.2			98.7	100	99.6	120.4			112.2	100	120.3	128.4	
33	Arkansas		101.8	100	108.1	141.5			104.1	100	108.8	161.1			100.1	100	107.5	127.9	
34	Florida		98.4	100	106.8	110.4			101.4	100	115.3	135.1			96.9	100	99.0	93.5	
35	Kentucky		94.8	100	105.8	109.5			98.7	100	106.4	114.1			83.3	100	104.2	94.9	
36	Kentucky		106.6	100	104.0	114.8			111.1	100	112.7	133.8			100.8	100	92.7	90.2	
37	Louisiana		87.9	100	109.0	117.0			85.8	100	114.2	121.1			92.2	100	98.2	108.5	
38	Missouri		86.5	100	111.6	115.9			84.7	100	124.3	142.8			89.4	100	103.1	97.8	

39	Missouri		100.9	100	104.4	115.6			98.7	100	112.8	122.8			104.5	100	91.3	104.3	
40	Missouri		101.8	100	108.3	139.9			105.8	100	108.1	138.2			99.8	100	104.6	96.2	
41	Missouri	90.4	88.0	100	108.9	114.2		94.7	99.6	100	104.5	132.2		95.0	79.1	100	112.5	100.3	
42	Tennessee		97.2	100	109.5	130.2			98.0	100	112.3	160.1			96.6	100	107.7	108.1	
43	Virginia		97.7	100	103.4	121.7			95.1	100	113.0	158.0			98.0	100	97.1	99.8	
44	West Virginia		100.9	100	105.8	108.5			79.3	100	94.3	110.4			119.2	100	115.3	106.9	
	Total		1270.2	1300	1397.4	1564.4			1261.0	1300	1426.3	1750.1			1272.1	1300	1252.5	1356.8	
	Average of group		97.7	100	107.5	120.3			97.0	100	109.7	134.6			97.9	100	96.3	104.4	
	Average of records		93.8	100	109.0	115.0			97.0	100	111.0	130.0			90.2	100	107.0	105.0	

Summary of Groups. Per cent of 1915

Western		101.7	100	107.3	109.5			98.6	100	109.9	117.4			103.6	100	104.3	105.3	
Central		95.7	100	110.1	112.8			99.7	100	121.9	141.1			90.9	100	103.0	90.4	
Eastern		98.3	100	109.1	111.4			100.9	100	109.3	137.3			97.3	100	110.0	98.5	
Southern		97.7	100	107.5	120.3			97.0	100	109.7	134.6			97.9	100	96.3	104.0	
Total		393.4	400	434.0	454.0			396.2	400	450.8	530.4			389.7	400	413.6	398.2	
Average of groups		98.3	100	108.5	113.5			99.0	100	112.7	132.6			97.4	100	103.4	99.5	
Average of records		96.6	100	106.0	109.0				100	106.0	119.0			87.0	100	106.0	102.0*	

TABLE 11—*Concluded*

Data arriving too late to be included in original tabulation

	GROSS ANNUAL REVENUE IN PER CENT OF 1915				OPERATING EXPENSES AND TAXES IN PER CENT OF 1915				OPERATING REVENUE, APPLICABLE TO DEPRECIATION, INTEREST, DIVIDEND AND SURPLUS IN PER CENT OF 1915			
	1914	1915	1916	1917	1914	1915	1916	1917	1914	1915	1916	1917
Eastern group												
New York City	98.5	100	112	100.2		100	99	88†		100	103.5	105

In reviewing these statistics—which indicate that in spite of drastic curtailment of operating expenses, the normal growth in revenue necessary to carry the increase in investment, the net revenue, is on the average declining—the difference in position of the water works having to pump and filter their supplies as compared with those having unfiltered, gravity supplies is to be remembered. The former are feeling the greater financial burdens in much greater measure than the latter.

* Value would be lower if large western water works were omitted.

† Reduction in operating expenses due to reduced pumping after introduction of Catskill supply.

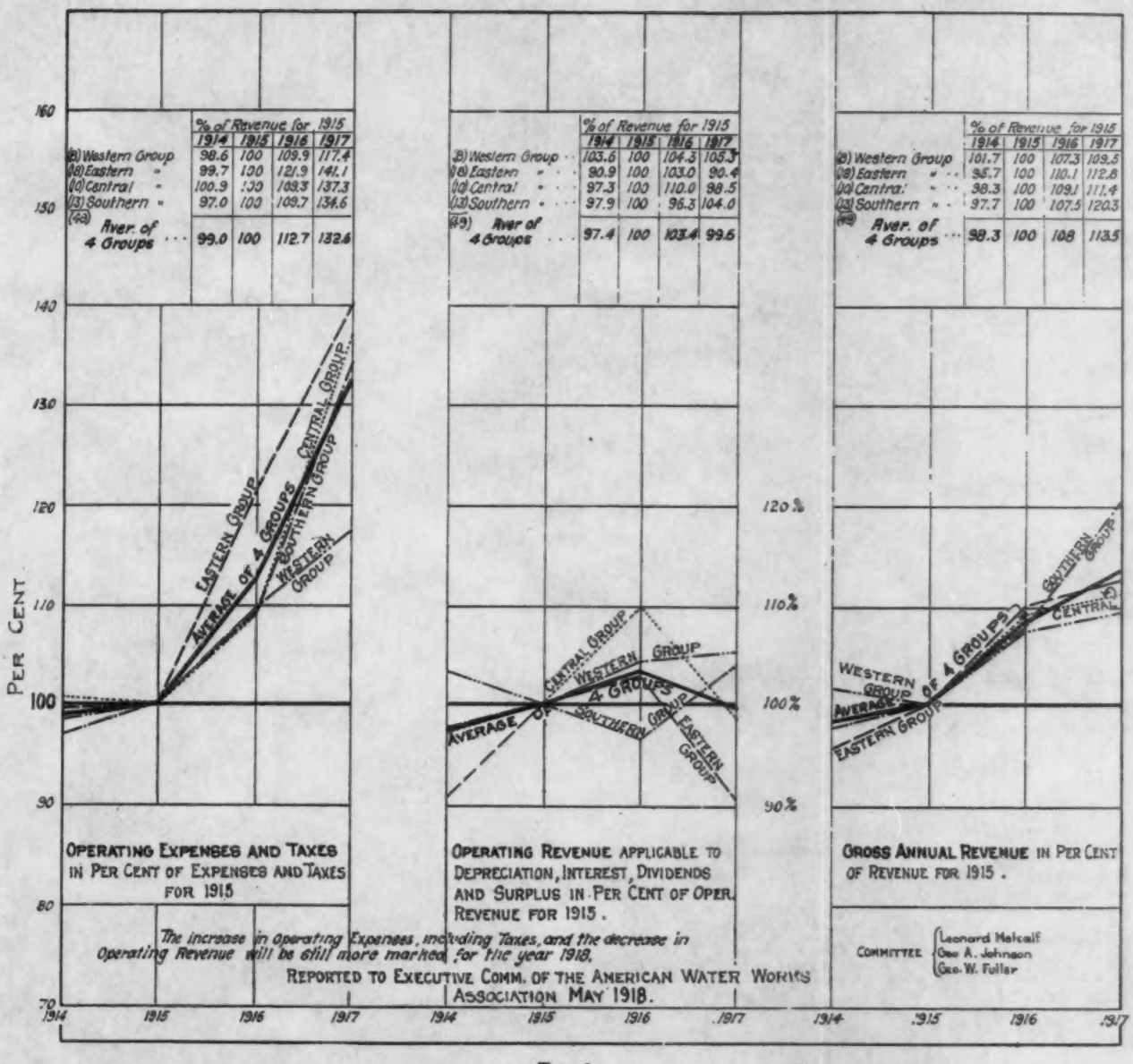

% of Revenue for 1915
1914 1915 1916 1917
(2) Western Group 98.6 100 109.9 117.4
(18) Eastern " 99.7 100 121.9 141.1
(10) Central " 100.9 100 109.3 137.3
(13) Southern " 97.0 100 109.7 134.6
(49) Aver. of 4 Groups 99.0 100 112.7 132.6
PER CENT
160
150
140
130
120
110
100
90
80
70
EASTERN GROUP
AVERAGE OF 4 GROUPS
CENTRAL GROUP
SOUTHERN GROUP
WESTERN GROUP
OPERATING EXPENSES AND TAXES IN PER CENT OF EXPENSES AND TAXES FOR 1915
% of Revenue for 1915
1914 1915 1916 1917
(2) Western Group 103.6 100 104.3 105.3
(18) Eastern " 90.9 100 103.0 90.4
(10) Central " 97.3 100 110.0 98.5
(13) Southern " 97.9 100 96.3 104.0
(49) Aver. of 4 Groups 97.4 100 103.4 99.6
120%
110%
100%
90%
CENTRAL GROUP
WESTERN GROUP
AVERAGE OF 4 GROUPS
SOUTHERN GROUP
EASTERN GROUP
OPERATING REVENUE APPLICABLE TO DEPRECIATION, INTEREST, DIVIDENDS AND SURPLUS IN PER CENT OF OPER. REVENUE FOR 1915.
% of Revenue for 1915
1914 1915 1916 1917
(2) Western Group 101.7 100 107.3 109.5
(18) Eastern " 95.7 100 110.1 112.8
(10) Central " 98.3 100 109.1 111.4
(13) Southern " 97.7 100 107.5 120.3
(49) Aver. of 4 Groups 98.3 100 108 113.5
WESTERN GROUP
AVERAGE OF 4 GROUPS
SOUTHERN GROUP
CENTRAL
EASTERN GROUP
GROSS ANNUAL REVENUE IN PER CENT OF REVENUE FOR 1915.
1914 1915 1916 1917
The increase in Operating Expenses, including Taxes, and the decrease in Operating Revenue will be still more marked for the year 1918.
REPORTED TO EXECUTIVE COMM. OF THE AMERICAN WATER WORKS ASSOCIATION MAY 1918.
COMMITTEE Leonard Metcalf, Geo A. Johnson, Geo. W. Fuller

FIG. 6

WATER WORKS OPERATION AND MAINTENANCE COSTS

Returns were received from about fifty important water works concerning their gross annual revenue, operating expense including taxes but excluding depreciation allowance, and the resulting operating revenue applicable to depreciation allowance, fixed charges, dividends and surplus. These results have been analyzed and put into comparative percentage form, in order that the change in conditions might readily be understood. Inasmuch as a number of these records were given in confidential manner, with the understanding that the names of the corporations would not be mentioned, there has been recorded merely the state in which the works were located. The works have been assembled in four major groups, the western, the central, the eastern, and the southern, and are shown in table 11. A summary of groups gives averages for each of the groups and the average of the four group averages, and the averages of all of the records cited.

These records indicate, as do the construction records, that no marked change in conditions was felt until 1916; that the gross annual revenues for 1916 and 1917 were respectively 6 and 9 per cent in excess of those for 1915, but slightly more than those for 1914 on the basis of all of the records received, or 8.5 and 13.5 per cent on the basis of the average of group averages. The normal advance in gross revenue, corresponding to the growth in population and in investment, would probably have exceeded 6 per cent per annum and may have been substantially greater than this amount.

The increase in operating expenses over those of 1914–1915 was 6 and 19 per cent for 1916 and 1917, respectively, on the basis of all the records received, and 12.7 and 32.6 per cent on the basis of the average of the group averages.

The resulting operating revenues applicable to the depreciation allowance, fixed charges, dividends and surplus for 1916 and 1917, were respectively 6 and 2 per cent in excess of those for 1915, all on the basis of the average of all of the records received; and 3.4 and 0 per cent, respectively, in excess of 1915, on the basis of the average of the four group averages.

Broadly speaking, therefore, it appears from table 11, as from the graphical representation shown in figure 6, that the increase in operating expense has substantially absorbed the normal increase in gross revenue and has left no revenue to carry the burden of

TABLE 12

Data on increase in operating expenses of some American water works

Under date of May 31, 1918, F. C. Jordan, Secretary of the Indianapolis Water Company, wrote independently to a number of the leading water plants of the country, requesting information in reference to their increase in operating expense, and readjustment of rates to offset, in part, this increased cost of operation. Up to June 10, 1918, answers had been received from about forty or fifty of these cities. These answers indicate the following increases in operating expenses during the past six months, as compared with the normal pre-war operating expenses.

Increase over normal operating expenses

		REPORTED INCREASE
		per cent
1	Savannah, Ga	20
2	Richmond, Va	25
3	Milwaukee, Wis	36
4	Brockton, Mass	28.6
5	Champaign, Ill	30
6	Nashville, Tenn	25
7	Mobile, Ala	30
8	Philadelphia, Pa	35
9	Jamestown, N. Y	56
10	Toledo, Ohio	32
11	St. Catherines, Ont	25
12	Elmira, N. Y	33
13	Worcester, Mass	35
14	Paterson, N. J	16
15	Cincinnati, Ohio	25
16	Springfield, Ill	20
17	Springfield, Mo	25
18	Springfield, Mass	17
19	Peoria, Ill	25
20	Jersey City, N. J	15
21	Decatur, Ill	35
22	Cleveland, Ohio	31
23	Des Moines, Iowa	47
24	Schenectady, N. Y	20
25	Xenia, Ohio	33
26	Flint, Mich	18
27	Providence, R. I	52
28	Colorado Springs, Colo	25
29	Atlanta, Ga	40
30	Kansas City, Mo	35
31	Dayton, Ohio	21
32	Lansing, Mich	30
Average		29

TABLE 12—*Concluded*

Quite a number of the water departments have increased their water rates within the past year or so, and others report that they are petitioning for an increase or contemplate doing so in the near future. Among those that have increased their rates are the following:

Atlanta, Ga., reduced its discount for prompt payment from 25 per cent to 10 per cent.

Cincinnati, Ohio, increased its rates 25 per cent, this increase affecting all water consumers.

Dayton, Ohio, increased its annual minimum on $\frac{5}{8}$-inch meters from $4.40 to $6.60. This amount covers a quarterly consumption of 1000 feet in addition to the meter rental.

Flint, Mich., increased the rate to its large consumers from 5 cents per thousand gallons to 8 cents.

Brockton, Mass., increased its rates to all consumers.

Philadelphia, Pa., increased its metered water rates 30 per cent.

Richmond, Va., increased its rates to large consumers from $3\frac{3}{4}$ cents per thousand gallons to 5 cents.

Detroit, Mich., put into effect an increase covering all consumers, and is now considering an additional increase.

Toledo, Ohio, increased its water rates on October 12, 1916, and is now figuring on another increase.

Savannah, Ga., increased its rates to all water consumers.

Toronto, Canada, increased its rates 10 per cent in 1917, and an additional increase of 25 per cent became effective in the early part of this year.

The following cities are petitioning for increase, or contemplate doing so in the very near future: Champaign, Ill.; Davenport, Iowa; Hamilton, Ohio; Racine, Wis.; Springfield, Mo.; Tampa, Fla.; Worcester, Mass.; Kent, Ohio, etc.

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additional investments. There is marked decline in revenue in the eastern group, however.

Interesting similar data on increase in operating expense of some of the more important water works in the United States were obtained by Mr. Frank C. Jordan, Secretary of the Indianapolis Water Company, and are given in table 12.

SUMMARY OF FINDINGS

Records received from 50 typically important water works in the United States, indicate

(a) That the advance in the cost of labor used by water works in construction work during the past three years was approximately 13 per cent in 1916 and 27 per cent in 1917, over the pre-war costs

in this country. These pre-war costs were fairly reflected by prices prevailing in the year 1915.

Material decrease in efficiency of labor has also been observed in all parts of the country, the consensus of opinion indicating an approximate loss in efficiency of from 25 to 35 per cent.

(b) The important water works construction materials, pipe, valves, hydrants, etc., have more than doubled in cost.

The more important operating materials, such as coal and fuel oil, have also more than doubled and chemicals for the treatment of the water have advanced from 50 to 100 per cent and more.

(c) The normal annual increase in revenue of the water works of this country has in general decreased, except where war activities have materially increased the local market for water.

(d) The operating and maintenance expenses have increased approximately one-third, the increase in gravity works being of less serious moment generally, than in the pumping plants.

(e) The net revenues applicable to depreciation allowance, fixed charges, dividends, and surplus have, in general, remained about stationary, instead of increasing substantially from year to year, thus indicating that the new investment is not being taken care of, and that the divisible revenue is declining. The conditions vary markedly at individual plants and in groups, the eastern group showing the most marked decline in net annual revenues. Unfortunately the conditions are growing more and more serious.

CONCLUSIONS

First. That the water works of the United States have suffered, through war conditions, large increase in construction and operation costs.

Second. That marked decline in net revenue has resulted.

Third. These conditions did not begin to make themselves generally felt until late in 1916, and it was not until the latter part of the following year that they became serious. The desirability and continuity of employment tended to delay the advance in wages.

Fourth. The advance in cost of labor used in extension and minor construction work, by water works in this country, has gathered force in the last six months, and it is the general opinion of municipal and corporate managers that additional increases are certain to come during 1918 and thereafter, if labor is to be held.

Fifth. It is undesirable to replace old, well-trained forces, familiar with these water works properties, with other labor not having this familiarity, in the effort to hold the wages at a point below the general local standard for similar service. The character of the service would suffer and it would not be fair to labor.

Sixth. Serious and conscientious effort has been made by water works operators generally to reduce construction and operating forces to a minimum.

These reductions have in many cases already gone beyond desirable limits, even to reducing the working efficiency of the properties.

In other cases still greater economies are possible in better consumption of coal; waste reduction by increased use of controlling meters, pitometer surveys, and more frequent house to house inspection, and in quarterly instead of monthly meter readings of small meters.

Seventh. The general situation is a very serious one and has shown itself in increasing difficulty of attracting capital for necessary betterments. While extension of service is likely to be increasingly limited with the conditions of war, it would be unfortunate, if the activities of important industrial and commercial centers, particularly those concerned in governmental activities, should be thus circumscribed.

Eighth. The menace of the situation lies in the increasing difficulty under such conditions of maintaining constantly a water service safe from a sanitary standpoint, necessary for good fire protection service, and adequate for industrial, commercial and domestic needs.

Ninth. Public Service Commissions and other regulatory bodies have already recognized the danger of the present situation to the public as well as to the utilities, and are likely at least to afford such relief as may seem to them necessary to maintain credit, but it is imperative for water works operators to keep clear records, showing the actual change in conditions and prices of materials and labor, that these bodies may have uncontestable proof upon which to pass judgment as to the necessity for relief.

Tenth. It is imperative, in the interest of good service, that water works operators of municipally as well as corporately owned plants, should anticipate their construction and operation needs, as far as possible, and should be careful to obtain the necessary priority orders, that the quality of the water and the service rendered may

not be seriously impaired in the future for want of construction and operation materials and supplies.

Respectfully submitted,

LEONARD METCALF, *Chairman*,
GEORGE A. JOHNSON,
GEORGE W. FULLER.

PROGRESS REPORT OF COMMITTEE ON MECHANICAL ANALYSIS OF SANDS

The Committee on Mechanical Analysis of Sand has up to this time delayed the preparation of a report principally because of the fact that it is thought to be one of the principal duties of this committee to submit a proposed standard method of conducting such analyses and because during the past two years, especially, the United States Bureau of Standards at Washington, D. C., has been active in securing coöperation and joint action of parties interested in the selection and adoption of standard screens. It is recognized that standard screens are required not only for the mechanical analyses of sands but also in many other industries, yet it is believed that it is to the best interests of all having to do with such sand analyses that the one standard be used for all. There are obvious advantages in having the one standard screen scale available for all purposes and there is no apparent advantage in having a separate or distinct set of standard screens for testing sand.

Early action of the Bureau of Standards in the matter of standardizing sieves resulted in the adoption of certain specifications standardizing 200 and 100-mesh sieves used primarily for testing cement. Subsequently, early in 1917, responding to the demands of industry, the Bureau of Standards called a conference at Washington including representatives of practically all national engineering and technical organizations and others interested in the adoption of standard sieves. The conference, after considering various screen scales, adopted a standard screen scale and recommended that it be adopted generally by scientific, technical, and engineering societies and committees as part of their specifications for materials and methods of tests; also that it be used by private firms who have need of standard sieves. The committee recommends the adoption of the standard screen scale for sieves used in the mechanical analysis of sands.

The screen scale is essentially metric. The sieve having an opening of 1.0 mm. is the basic one and the sieves above and below this in the series are related to it by using in general the square root

of 2, or 1.4142, or the fourth root of 2, or 1.1892, as the ratio of the width of one opening to the next smaller opening. The first ratio, that is, 1.4142, is used for openings between 1.0 mm. and 8.0 mm., while the second ratio is used for openings below 1.0 mm. to give more sieves as required in that part of the scale.

Because of the possible wide range of openings in sieves now manufactured with a given number of meshes of wire per unit length, due to the use of wires of different diameters, and because of the consequent confusion and uncertainty which arise in designating sieves by the number of meshes per unit length, the sieves of this series are designated by the width of the opening in millimeters, as for example a 1.41 mm. sieve, or a 0.36 mm. sieve. The committee recommends that this method of designating sieves be adopted instead of the customary method of designating the number of meshes per inch.

To meet the need for sieves of this series at the present time the committee has included a temporary provision in the specifications for the acceptance of sieves of slightly different mesh and wire diameter than that called for in the screen scale, provided the resultant opening is the same as the nominal opening within a small range. This will make possible the use of a number of sieves now on the market in which the ratios of wire diameter to opening are only slightly different from those of the screen scale.

Specifications for standard sieves

Sieves shall be of brass constructed in diameters of 20 cm. (7.87 inches) or 15 cm. (5.91 inches). These are the outside diameters of the bottom of the sieves or the inside diameters of the top of the sieves.

Wire cloth for standard sieves shall be woven (not twilled, except that the cloth of 0.062-mm. sieves, may be twilled until further notice) from brass, bronze, or other suitable wire and mounted on the frames without distortion. To prevent the material being sieved from catching in the joint between the cloth and the frame, the joint shall be smoothly filled with solder, or so made that the material will not catch.

The number of wires per centimeter of the cloth of any given sieve shall be that shown in the accompanying table 1, in the second column, headed "Mesh," and the number of wires in any whole centimeter shall not differ from this amount by more than the tolerance given in the 5th column, that headed "Mesh" under the heading "Tolerances." No opening between adjacent parallel wires shall be greater than the nominal width of opening for that sieve by more than the following amounts:

Five per cent of the nominal width of opening for the 8-mm. to 1-mm. sieve inclusive.

TABLE 1

Standard screens for mechanical analyses of sand

	WIDTH OF OPENINGS	MESH	WIRE DIAMETER	RATIO WIRE DIAMETER TO OPENING	TOLERANCES	
					Mesh	Diameter
Metric	8.00	1.00	2.00	0.25	0.01	0.008
Customary	0.315	2.54	0.079	0.25	0.03	0.003
Manufactured	8.05	2.5	0.083	0.26		
Metric	5.66	1.4	1.48	0.26	0.01	0.08
Customary	0.223	3.56	0.056	0.26	0.03	0.003
Manufactured	5.66	3.5	0.063	0.28		
Metric	4.00	2.0	1.00	0.25	0.02	0.05
Customary	0.157	5.1	0.039	0.25	0.05	0.002
Manufactured	4.04	5.0	0.041	0.26		
Metric	2.83	2.75	0.81	0.29	0.02	0.05
Customary	0.111	7.0	0.032	0.29	0.05	0.002
Manufactured	2.82	7.0	0.032	0.29		
Metric	2.00	3.9	0.56	0.28	0.04	0.05
Customary	0.079	9.9	0.022	0.28	0.1	0.002
Manufactured	2.03	10.0	0.020	0.25		
Metric	1.41	5.0	0.59	0.42	0.08	0.025
Customary	0.0555	12.7	0.0232	0.42	0.2	0.001
Manufactured	1.42	12.0	0.027	0.69		
Metric	1.00	7.0	0.43	0.43	0.15	0.020
Customary	0.394	17.8	0.0169	0.43	0.4	0.0008
Manufactured	1.01	18.0	0.016	0.41		
Metric	0.71	9.0	0.40	0.56	0.3	0.012
Customary	0.0280	22.9	0.0157	0.56	0.75	0.0005
Manufactured	0.72	22.0	0.017	0.60		
Metric	0.50	12.0	0.33	0.66	0.4	0.012
Customary	0.0197	30.5	0.0130	0.66	1.0	0.0005
Manufactured	0.50	3.0	0.0135	0.68		
Metric	0.36	16.0	0.26	0.72	0.6	0.010
Customary	0.0142	40.6	0.0102	0.72	1.5	0.0004
Manufactured	0.36	40.0	0.011	0.79		

TABLE 1—*Concluded*

	WIDTH OF OPENINGS	MESH	WIRE DIAMETER	RATIO WIRE DIAMETER TO OPENING	TOLERANCES	
					Mesh	Diameter
Metric	0.25	23.0	0.185	0.74	1	0.008
Customary	0.0098	58.4	0.0073	0.74	3	0.0003
Manufactured	0.25	60.0	0.007	0.72		
Metric	0.17	31.0	0.15	0.88	1	0.008
Customary	0.0067	78.7	0.0059	0.88	3	0.0003
Manufactured	0.17	80.0	0.00575	0.85		
Metric	0.125	47.0	0.089	0.71	1.5	0.008
Customary	0.0049	119.4	0.0035	0.71	4	0.0003
Manufactured	0.119	120.0	0.0036	0.77		
Metric	0.088	67.0	0.061	0.69	2.5	0.005
Customary	0.0035	170.2	0.0024	0.69	6	0.0002
Manufactured	0.089	170.0	0.0024	0.69		
Metric	0.062	98.0	0.040	0.65	3.5	0.005
Customary	0.0024	248.9	0.0016	0.65	9	0.0002
Manufactured	0.061	250.0	0.0016	0.67		

Ten per cent of the nominal width of opening for the 0.71-mm. to the 0.36-mm. sieve, inclusive.

Twenty per cent of the nominal width of opening for the 0.25-mm. to the 0.125-mm. sieve, inclusive.

Thirty per cent of the nominal width of opening for the 0.088-mm. and the 0.62-mm. sieve, inclusive.

The diameters of the wires of the cloth of any given sieve shall be that shown in the third column of table 1 headed "Wire Diameter," and the average diameter of the wires in either direction shall not differ from the specified diameter by more than the tolerance given in the last column of table 1, that under "Tolerances" headed "Diameter."

Sieves shall be rejected for obvious imperfections in the sieve cloth or its mounting, as for example, punctured, loose or wavy cloth, imperfections in soldering, etc.

Until further notice, to permit the use of sieves now on the market which have slightly different mesh and wire diameters from that specified above, sieves will be satisfactory if the measurements of mesh and wire diameters show the resulting average width of opening to be within 4 per cent of the nominal opening of a given sieve, and the ratio of wire diameter to opening of the sieve in question is within 0.03 of that given in table 1, in the column headed "Ratio Wire Diameter to Opening" for the 8-mm. to the 2-mm. sieves, inclusive, and within 0.06 of the ratio given for sieves of smaller openings than 2 mm.

The Bureau of Standards has announced that it will test sieves of the standard screen scale to determine whether they conform to the specifications which follow. This test will consist of an examination of the mesh of both the warp and shoot wires of the cloth to ascertain whether it comes within the tolerances allowed; also measurements of the diameter of wires in each direction to determine the average diameter; also a measurement of any large openings to determine whether they exceed the limits given in these specifications; also, an examination of the sieves to discover any imperfection of the sieve which may seriously affect its sieving value. Sieves which pass the specifications will be stamped with the seal of the Bureau and will be given an identification number and a certificate will be furnished for each sieve that passes the requirements.

For sieves which fail to meet the specifications reports will be rendered showing wherein the sieve was not up to the standard.

In the accompanying Table 1 the committee has shown the specifications for standard screens which it recommends for adoption by the Society. The first 7 sieves listed, that is from the 8-mm. to the 1.0-mm. sieve, include the first 7 sieves of the entire screen scale. For the sieves smaller than the 1.0 mm. sieve, only the alternate sieves of the screen scale are included.

In the table are shown the meshes per inch and diameters of wire, together with their tolerances, all expressed in millimeters and inches. Widths of openings are expressed also in millimeters and inches. There is also shown for each standard screen specifications for that sieve now manufactured which most nearly approaches the suggested standard screen, as regards width of opening and ratio of wire diameter to opening.

The committee wishes to call attention to the importance of the latter factor or ratio. Referring to the table, it will be observed that the ratio of wire diameter to opening varies from 0.25 to 0.88, generally increasing with the finer cloth. In practice it is found that the diameter of wire used should be as small as will withstand the service required, because material will not pass cloth composed of coarse wire so freely as it will pass cloth woven of fine wire. This fact undoubtedly is the principal reason why confusion has arisen in the past when it has been attempted to establish a relation between the diameter of opening and the size of the particle passing the opening, that is the separation of the sieve. For instance, in

the case of two sieves having the same width of opening, that in which the wire has the larger diameter will pass the larger particle, and vice versa.

Another feature of the manufacture of wire cloth which has considerable importance in affecting the separation of a screen is the weave. The finer screens are frequently made of twilled cloth, that is each wire crosses above and below each adjacent two wires, while in the plain woven cloth, each wire crosses above and below each adjacent wire. The plain woven cloth is always used for the coarser sieves. Experience shows that larger particles will pass through twilled cloth than through plain woven cloth of the same width of opening.

The committee recommends that the cloth in all of the standard sieves be plain woven and not twilled, although for the present it may be necessary to use twilled cloth for the 0.062 mm. sieve.

Methods of making mechanical analysis. A mechanical analysis of sand is generally accomplished in the following manner: The selected sieves are nested with the coarsest at the top varying to the finest at the bottom. For the 8 inch diameter sieves 300 grams and for the 6-inch sieves 100 grams of the sand to be analyzed are dried and placed in the top sieve, the nest of sieves is shaken in a mechanical shaker practically to refusal of any further separation, the sieves separated, and beginning with the finest sieve the sand remaining on each sieve is weighed accumulatively. The results are then plotted to a suitable scale.

There are six factors which control the results of a mechanical analysis, as follows: the selection of a representative sample; the quantity of material taken for analysis; the number and rapidity of the shakes; the accuracy of the weights of the separated portions; the rating of the sieves to determine their separations; and finally, the interpretation of results. Each of the above features has an important bearing on the accuracy and reliability of a mechanical analysis and should be given proper consideration.

The material to be analyzed should preferably be in its natural moist condition when sampled as otherwise it tends to separate. When dry it should be handled with a scoop and thoroughly mixed. In sampling a pile of moist sand a large sample should first be taken of several portions from different parts of the material, these portions mixed, the resultant sample quartered and the process continued until finally there is secured a sample of the required size.

The amount of sand used should be as large as practicable. For the 8-inch sieves 300 grams of graded sand and for the 6-inch sieves 100 grams may well be used. More than these quantities tend to stretch and clog the cloth and are not readily separated by shaking.

A mechanical shaker is required, especially where a large number of analyses are to be made. Several satisfactory machines are on the market. The essential feature of such a machine is that its speed shall be properly controlled. Experience will readily indicate the period of shaking required in the machine which should be operated by trial, using the required amount of sand until there is practically no further passage of sand grains through the screens.

In the case where a mechanical shaker is not available, as in field work, hand shaking when carefully executed will give results commensurate with a mechanical shaker. Experience indicates that when using the portions of sand indicated above, hand shaking for about 200 double horizontal shakes will give a satisfactory separation.

The accuracy of the weighing depends upon the precision of the balance used. Weights should be taken to 0.1 gram, with the understanding that the weights may be slightly in error when the total weight is greater than 100 grams.

The interpretation of a mechanical analysis depends primarily upon two features, the size of separation as determined for each sieve and the method of plotting and recording results.

At least two methods are available to determine directly the separation of a sieve, either to measure the three principal diameters of representative sand grains and to compute their average diameter or to count and weigh the grains and to compute the volume of the average particle obtained by dividing the weight of the average grain by its specific gravity. There is thus obtained the mean volume of the average grain which is considered to be a sphere and its diameter computed and taken as the separation of the sieve. The former procedure is recommended as giving the best results for large gravel; also for the extremely small grains of sand such as will pass a sieve of 200 meshes to the inch. A pair of calipers may be used to measure the diameters of the larger particles and a microscope to measure the smaller particles. The second procedure is the one commonly used for sieves ranging from 4 to 140 meshes per inch and requires the accurate separation of the sample, the counting and weighing of the grains and the determination of the specific

gravity of the grains. It will be observed that the rating of a nest of sieves in this manner is at best a tedious and difficult procedure.

Whatever the method used in determining the sizes of the grains the securing of an accurate sample is of first importance. The procedure is as follows: a sample of sand is put through the sieve in exactly the same manner as in making a mechanical analysis. Each sieve is then shaken a little by hand and the last particles going through are shaken over the next finer sieve. The last material remaining on the next finer sieve is considered the separation of the sieve.

Experience indicates that the results of the determinations of the sizes of separation are dependent almost entirely upon the selection of proper samples, because two determinations of the separation of a sieve using portions of the same sample should give the same results to the required accuracy when reasonable care is used. Owing to characteristic variation in the sizes and shapes of the grains it is desirable to use several kinds of sand from different locations or sources in order to determine the average separation. Where sieves are required largely for the mechanical analysis of a particular sand the procedure may properly be limited to determinations of the sizes of separation with this material only.

A comparative method of rating sieves also suggests itself in the event that there is available a nest of sieves already rated. A representative sample of sand may then be analyzed in the usual manner by the rated sieves and again may be separated into weighed portions by the unknown sieves. By plotting the percentages of the total weight on the curve of the analysis as determined by the first set sieves, the separations of the unknown sieves may be read directly. The comparative method has obvious advantages and in general is one of the methods now used by the Bureau of Standards to test 100 and 200 mesh cement sieves.

Because the method of rating a nest of sieves by counting and weighing the grains is a very tedious and expensive procedure, investigations have been made from time to time to determine whether or not there is any definite relation or relations between the width of opening of a screen and the size of separation. In view of the fact that in the past screens have been made with little if any attention to definite specifications or tolerances of mesh and diameters of wire it is not surprising that these investigations were not satisfactory and did not indicate whether or not such a relation exists.

Part of the difficulty undoubtedly was attributable to the personal factor and also to the use of grains of sand of different degrees of sharpness.

In table 2 are shown the openings of the standard screens and the probable sizes of separation that may be obtained with sieves built under the accompanying specifications, especially in regard to tolerances of mesh and diameter of wire. Experience indicates that

TABLE 2

Relation between sizes of opening and sizes of separation of sieves

SIEVE OPENING	MESH	RATIO WIRE DIAMETER TO OPENING	RATIO SIZE OF SEPARATION TO OPENING	CORRESPONDING SIZE OF SEPARATION
mm.	*inches*			*mm.*
8.00	2.54	0.25	1.09	8.72
5.66	3.56	0.26	1.09	6.17
4.00	5.1	0.25	1.09	4.36
2.83	7.0	0.29	1.09	3.08
2.00	9.9	0.28	1.09	2.18
1.41	12.7	0.42	1.10	1.55
1.00	17.8	0.43	1.10	1.10
0.71	22.9	0.56	1.10	0.78
0.50	30.5	0.66	1.10	0.55
0.36	40.6	0.72	1.11	0.40
0.25	58.4	0.74	1.11	0.28
0.17	78.7	0.88	1.11	0.19
0.125	119.4	0.71	1.11	0.14
0.088	170.2	0.69	1.11	0.10
0.062	248.9	0.65	1.20*	0.07

* Ratio assumed for twilled cloth. For plain woven cloth ratio is 1.11 and separation is 0.068 mm.

many sieves used for the mechanical analyses of sand would not come within these specifications especially because the spacing of the wires in one direction is not correct and within these specifications. Moreover it is not uncommon to find the wires used in the cloth to be of larger diameter and unsatisfactory on this account.

The Committee is not in accord as to the value of factors to be applied to determine the separation of a sieve with relation to its average width of opening. It is obvious, however, that the use of the accompanying specifications should result in a material improvement in the manufacture of testing screens; also that the use of such factors would be of great assistance in many cases in determining

the relation between analyses made by different investigators and expressed by either one of the two standards of measurement. Moreover, it is apparent that the use of the standard screens in specifications of material required has obvious advantages as compared with the use of such terms as will define the sizes of the particles, or of selected arbitrary percentages by weight of the particles.

Furthermore, the Committee is not in accord as to the standard of measurement which can best be adopted for rating sieves required for the mechanical analysis of sand. It is of course true that the principal use of such analyses, so far as this Association is concerned, is for the determination of the characteristics of sand required or used for filtration purposes. Moreover, up to the present time, the standard of measurement has been the size of separation of a sieve and not the width of opening. The screen scale now recommended by the Bureau of Standards for adoption is based upon the width of opening and not upon the size of separation. The committee is not yet prepared to report upon the adoption or uses of either standard of measurement because further investigation is required to reach a conclusion in this matter.

PHILIP BURGESS, *Chairman.*

AMENDMENTS TO THE CONSTITUTION[1]

AMENDMENTS TO ARTICLE III

This amendment qualifies for Active Membership, engineers, chemists, and other technical men, who act as such for, and are employed by, Associate Members of the Association. It is felt that in the past numerous persons well qualified for Active Membership have been improperly debarred from that grade through their employment by Associate Members. Section 3 as amended follows:

SECTION 3. An active member shall be either a superintendent, manager, or other officer of a municipal or private water works; a civil, mechanical, hydraulic or sanitary engineer, chemist or bacteriologist, including those acting technically as such for, and employed by, Associate Members of the Association; or any qualified person engaged in the advancement of knowledge relating to water supplies in general.

AMENDMENT TO ARTICLE VI

This is a highly important amendment affecting the manner of electing officers of the Association. The proposed amendment seeks to evenly balance the control of Association affairs by dividing the membership into six districts, each of which will have approximately the same number of members, and according to the plan herein proposed each of these six districts will always have representation on the Executive Committee. No one of the districts will be represented by more than one Trustee at any time. The term of office of Trustees will be three years in each case, two being elected each year in the districts in which the terms of the incumbents expire.

The new method of electing the Nominating Committee herein proposed is believed to be a marked improvement over the present. It provides that at the Annual Meeting each district shall submit one name, but not more than two, as candidates for the Nominating

[1] Submitted by the Special Advisory Committee, approved by the Executive Committee, December 1, 1917, and adopted by the St. Louis Convention on May 14, 1918.

Committee from that district. The names so submitted at the Annual Meeting, together with any others sent to the Secretary within sixty days after the Annual Meeting, are to be printed on a ballot and mailed to the voting membership of each district. Voting is not restricted to such names. Balloting on the election of members of the Nominating Committee follows in the same manner as that provided for the election of officers. The candidates receiving the largest number of votes for membership on the Nominating Committee thus selected by their respective districts, and the latest living past-President of the Association, are then formally appointed by the Executive Committee as the Nominating Committee.

This Nominating Committee, composed of seven members, one being elected from each of the six districts, and the latest living past-President, will meet on or before January 1st for the purpose of selecting nominees for the offices to be filled. Reimbursement for their expenses is provided for. The Committee selects but one nominee for each office to be filled, first obtaining the consent of the nominee to accept nomination and to serve if elected. On or before January 10th the Nominating Committee shall report its list of nominees to the Secretary of the Association, and on or before February 1st the Secretary shall mail to the membership this list of nominees selected by the Committee.

Other nominees may be made by petition before March 1st, and the balloting for officers will follow in the usual manner. Article VI as amended is as follows:

SECTION 1. The officers of the Association shall be a President, Vice-President, Treasurer, Secretary and Editor of the Association's publications. The offices of the Secretary and Editor may be combined at the discretion of the Executive Committee.

SECTION 2. There shall be an Executive Committee in which the government of the Association shall be vested. It shall consist of the President, Vice-President, Treasurer, Secretary, Editor, the Chairman of the Finance Committee, the latest two living past-Presidents and six Trustees elected to represent the six districts hereinafter established, one Trustee to be elected from each district to serve three years. The President and Secretary of the Association shall be the President and Secretary of the Executive Committee.

In 1919 one Trustee shall be elected from District 1, and one from District 4, to succeed the present Trustees whose terms expire in 1919; in 1920 one Trustee shall be elected from District 2, and one

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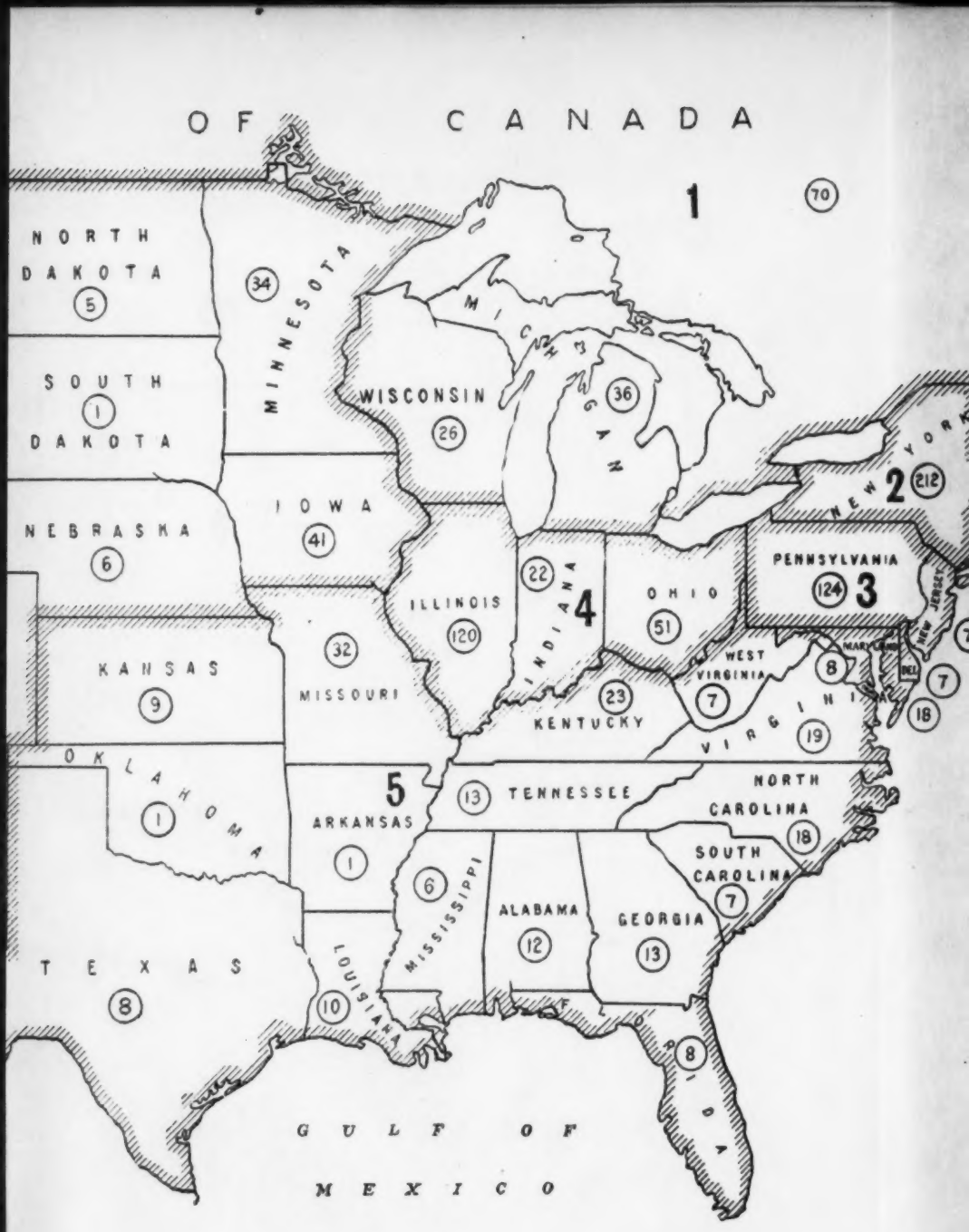
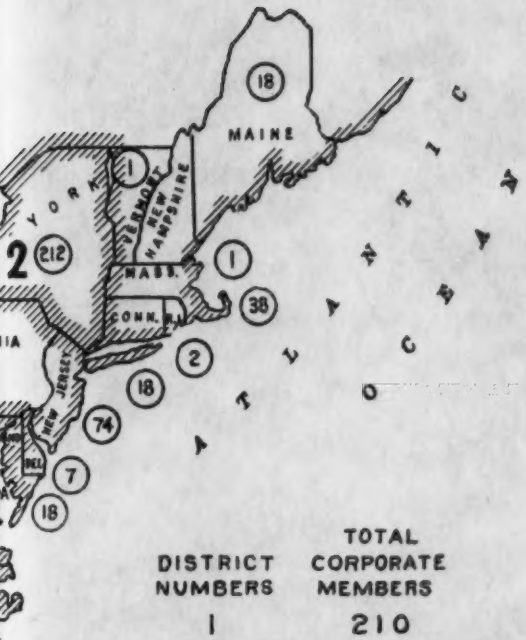


AMERICAN WATER WORKS ASSOCIATION

PECIAL ADVISORY COMMITTEE ON THE CONSTITUTION

HICAL DISTRIBUTION OF VOTING MEMBERSHIP

(TOTAL IN 1917 WAS 1237)



DISTRICT NUMBERS	TOTAL CORPORATE MEMBERS
1	210
2	212
3	205
4	193
5	213
6	204
TOTAL	1237

HIP

from District 5 to succeed the present Trustees whose terms expire in 1920; in 1921 one Trustee shall be elected from District 3, and one from District 6, to succeed the present Trustees whose terms expire in 1921; and every year thereafter, two Trustees shall be elected in the districts in which the terms of the incumbents expire.

SECTION 3. The following districts are established for the purpose of territorial representation:

District 1 shall include the States of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, Michigan, Wisconsin and the Dominion of Canada.

District 2 shall include the State of New York.

District 3 shall include the States of New Jersey, Pennsylvania and Delaware.

District 4 shall include the States of Ohio, Indiana and Illinois.

District 5 shall include the District of Columbia and the States of Maryland, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Tennessee, Kentucky, Arkansas, Louisiana, Kansas, Oklahoma and Texas.

District 6 shall include all other States and Territories of the Union, and all territory outside of the United States not otherwise provided for.

The boundary lines of these districts may be changed by majority vote of the Association at any time when it becomes necessary so to do in order to preserve approximately the same number of voting members in each district. Should any Trustee be thrown into another district by changes made in the boundary lines, he shall serve out his term of office and be accredited as the representative either of his old district or of the district in which he resides, as the Executive Committee may determine.

SECTION 4. On or before the first day of November of each year, the Executive Committee shall appoint a Nominating Committee composed of seven members, one from each district, together with the latest living past-President of the Association who shall be the Chairman of the Committee. The district members thus appointed shall be those active, honorary or corporate members who receive from their respective districts the largest number of votes of the general membership obtained in the following manner: members from each district present at the Annual Meeting shall submit one name and may submit two, but not more, from members from that district, as candidates for the Nominating Committee for that dis-

trict; the names submitted, together with any others sent to the Secretary within sixty days after the Annual Meeting, over the signatures of at least twenty-five voting members from the district for which the candidate is to be elected, shall be printed on a ballot and mailed to the voting membership of each district not later than the first day of October following, but voting shall not be restricted to such names. The polls shall be closed at the Secretary's office at noon October 20th. The said ballots for each district shall have only the names of the candidates for that district printed thereon with space left for inserting another name by the voter. The method of balloting shall be the same as that provided hereafter for election of officers. Should there be a tie vote in any district, the Executive Committee shall decide by vote which of the candidates receiving the largest number of votes shall be appointed.

On or before the first day of January following, the Nominating Committee so elected shall meet at some convenient point for the purpose of selecting nominees for the offices to be filled. Railroad fares of the members of the Committee attending this meeting, on the basis of an allowance of four cents per mile of travel, shall be paid by the Association after the accounts have been approved by the Chairman of the Nominating Committee and by the Finance Committee. The Nominating Committee shall select only one nominee for each office to be filled, after obtaining the consent of the nominee to accept nomination and to serve if elected.

On or before January 10 the Nominating Committee shall report its list of nominees to the Secretary of the Association, who shall before the first day of February cause to be mailed to the membership the list of nominees selected by the Nominating Committee. At any time prior to noon on the first day of March of each year additional nominations may be made by request to the Secretary, signed by at least twenty-five Active, Honorary or Corporate members, and upon the receipt of such request the Secretary shall, after acceptance of the nomination by the candidate, add such additional nominees to the final ballot to be prepared by him. The nominees of the Nominating Committee shall head such final ballot for each office, and any additional nominees for the respective offices shall be placed under the nominees of the Committee in alphabetical order.

SECTION 5. Election shall be by letter ballot. At least two months before the date of the Annual Meeting, a ticket shall be mailed to each member of the Association entitled to vote. Each

member shall be entitled to vote for one candidate for President, one candidate for Vice-President, one candidate for Treasurer and two candidates for Trustees. The ballot shall be sealed separately in a special ballot envelope. This ballot envelope shall be enclosed in a larger envelope and forwarded to the Secretary. The signature of the member voting shall appear on the outer envelope.

The Secretary with two canvassers appointed by the President shall meet at a time and place directed by the President, and shall open and count all ballots cast by persons entitled to vote. No ballot shall be counted if received later than noon of the seventh day previous to the beginning of the Annual Meeting.

The result of the canvass for President, Vice-President,Treasurer and Trustees shall be declared by the President at the Annual Meeting on certification of the canvassing board. The members who shall have received the highest number of votes cast for the several offices shall be declared elected. If there be a tie vote the President shall order a vote to be taken in the Annual Meeting to decide which person of those who shall have received the same number of ballots shall be chosen.

The terms of the officers so elected shall be as follows: For the President, Vice-President, and Treasurer, each one year beginning with the close of the last day of the Annual Meeting and ending the last day of the next Annual Meeting, or until their successors shall have been chosen; for the Trustees, three years beginning with the close of the last day of the Annual Meeting, or until their successors shall have been chosen.

SECTION 6. Before the close of each Annual Convention, the Executive Committee elected to serve during the year ensuing, shall organize and elect a Secretary and an Editor, to serve until the close of the next Annual Convention, or until their successors are chosen.

SECTION 7. In case of inability of the President to perform the duties of his office, his position shall be temporarily filled by the Vice-President, and in case of inability of the Vice-President, his position shall be filled by one of the Trustees; the order of precedence being governed by priority in date of election as Trustee, or if the dates of election be the same, by priority in date of the admission of such Trustees to membership in the Association.

SECTION 8. All vacancies in office, except as provided in Section 7 hereof, shall be filled by vote of the Executive Committee for the unexpired term of said office as soon as practicable after said vacancy occurs.

SECTION 9. The President, Vice-President and Trustees shall be ineligible to election to the same office for consecutive terms.

AMENDMENT TO ARTICLE VIII

This proposed amendment is in the line of an endeavor to improve the present method of selecting places for holding Annual Conventions. Heretofore much valuable time during the Annual Meetings has been unnecessarily consumed in selecting the next Annual Meeting place. This amendment creates a Convention Committee, to be appointed each year by the incoming Executive Committee. This is to be a committee of three, one of whom is to be the Secretary of the Association. Its duty is to investigate all invitations from cities, and to satisfy itself that proper facilities are available for all purposes of the convention. During each Annual Meeting this committee will hold a meeting at which advocates of the various places extending invitations will be heard. The Convention Committee will report its findings to the Executive Committee, and the Executive Committee to the Convention, and after a place has been selected one or more of the Convention Committee will visit the place selected and ascertain whether the guarantees can be satisfactorily carried out, and if so make the necessary arrangements. Reimbursement for the expenses of the committee is provided for. The proposed amendments to Article VIII follow:

SECTION 1. There shall be four standing Committees, the Finance Committee, the Membership Committee, the Publication Committee and the Convention Committee. The members of each shall be appointed by the incoming Executive Committee. They shall serve for one year beginning with the close of the last day of the Annual Meeting or until their successors shall have been appointed. Special Committees may be appointed at any time by the President.

Add a new section numbered 5 to Article VIII to read as follows:

SECTION 5. The Convention Committee, which shall consist of three members, one of whom shall be the Secretary, shall investigate all invitations to hold conventions of the Association, satisfying itself that the places extending the invitations have proper facilities for the accommodation of the members and guests, for holding the meetings of the Association with its National Sections, and for exhibits by associate members. This Committee shall invite the

Convention Committee of the Water Works Manufacturers' Association to coöperate with it. The Committee shall prepare and send to all cities extending invitations to hold conventions a form containing such questions as may be necessary to properly inform the Committee as to the convention facilities offered. The information shall include a diagram of the rooms offered for meeting rooms, Committee and Section rooms and exhibition space, also a list of available hotels, with guaranteed rates and the number that each will accommodate; points of interest to water works people, and entertainment, if any, offered.

During each Annual Convention the Committee shall hold a meeting, at which advocates of various places extending invitations shall be heard, and at the time designated by the Executive Committee for the selection of the place for holding the next Annual Convention the Committee shall make a report to the convention, stating in alphabetical order the invitations received and fully and impartially set forth the advantages and facilities offered by each. Should no invitations be received it shall be the duty of the Committee to ascertain what arrangements can be made for holding a convention, and to report to the Executive Committee before the convention convenes.

The Committee, or one or more members of the Committee, may, as soon as practicable after the place for holding a convention has been selected, visit such place and ascertain whether the guarantees can be fully carried out, and whether it is a suitable place for holding a convention of the Association; also, if the place is approved, to make the necessary arrangements for holding the convention. If, after such visit, it is the judgment of the Committee that the place is not suitable, or does not offer proper facilities, or for any other reason it would not be for the best interests of the Association to hold its convention there, the Committee shall immediately report its findings to the Executive Committee, with its recommendations as to the meeting place for the next Annual Meeting. The expenses of the Committee or members of the Committee, in making such visits to be borne by the Association, on the basis of an allowance of four cents per mile travel.

AMENDMENTS TO ARTICLE X

This proposed amendment seeks to clarify the somewhat ambiguous phrasing of the laws governing expenditures by local sections. Its passage is particularly recommended by the Finance Committee

on account of certain misunderstandings which arose last year with respect to the manner in which the expenses of sections should be financed. As amended Section 4 of Article X is as follows:

SECTION 4. Each Local Section as soon as established, and after its rules have been approved by the Executive Committee, may, with the approval of the Finance Committee, annually receive from the Treasurer of the Association, for local use, not more than twenty-five per cent of the annual dues paid to the Association by the members of the said Local Section; except that in no case shall the total of all moneys received by any Local Section for any one fiscal year exceed the sum of One Hundred and Fifty Dollars; and except that Local Sections with small memberships, where the alloted twenty-five per cent of the annual dues paid to the Association by the members of the said Local Section does not amount to Fifty Dollars, such Local Sections shall be entitled to receive from the Treasurer of the Association, for local use, not more than Fifty Dollars in any one fiscal year.

The Treasurer of each Local Section shall forward to the Secretary of the Association his application endorsed by the presiding officer of the Section for such portions of the said sums above specified as may be needed; and upon receipt of such application the Secretary shall request the Finance Committee to authorize the Treasurer of the Association to pay such sums to the Treasurer of the Local Section. These moneys may be used by the Local Section only in payment of necessary operating expenses incurred by the Section, such as printing, stationery, postage, rent and care of meeting room, light, fuel, stenographer and stereopticon operator services at meetings, etc.

At the end of each fiscal year the Treasurer of each Local Section shall submit a certified copy of his accounts to the Secretary of the Association, the same being itemized and showing the balance on hand of the funds received from the Association. This balance shall be returned to the Secretary of the Association, or shall be charged to the Local Section as a portion of its quota for the following year.

SPECIAL ADVISORY COMMISSION ON THE CONSTITUTION.

George A. Johnson, *Chairman.*
Morris R. Sherrerd,
Carleton E. Davis,
Garrett O. House,
Edward E. Wall.

SOCIETY AFFAIRS

PROCEEDINGS THIRTY-EIGHTH ANNUAL CONVENTION

The Thirty-eighth Annual Convention of the American Water Works Convention was held at the Planters' Hotel, St. Louis, Missouri, May 13–17, 1918, an exhibit by the members of the Water Works Manufacturers' Association being held concurrently at the same hotel. Although the constitution requires the opening session to be held on Tuesday, an informal meeting was held on the evening of Monday, May 13. Water Commissioner Edward E. Wall., of St. Louis, introduced Mayor H. W. Keil, who delivered an address of welcome, which was responded to by Past President Leonard Metcalf. A reception and dance followed, by invitation of the Local Entertainment Committee, of which Commissioner Wall was chairman.

Tuesday Morning, May 14. Major Theodore A. Leisen, Q.M.R.C., President of the Association, being unable on account of official duties to be present at this time, the session was called to order at 9.00 a.m., by the Vice President, Allen W. Cuddeback, who presided during the greater part of the convention.

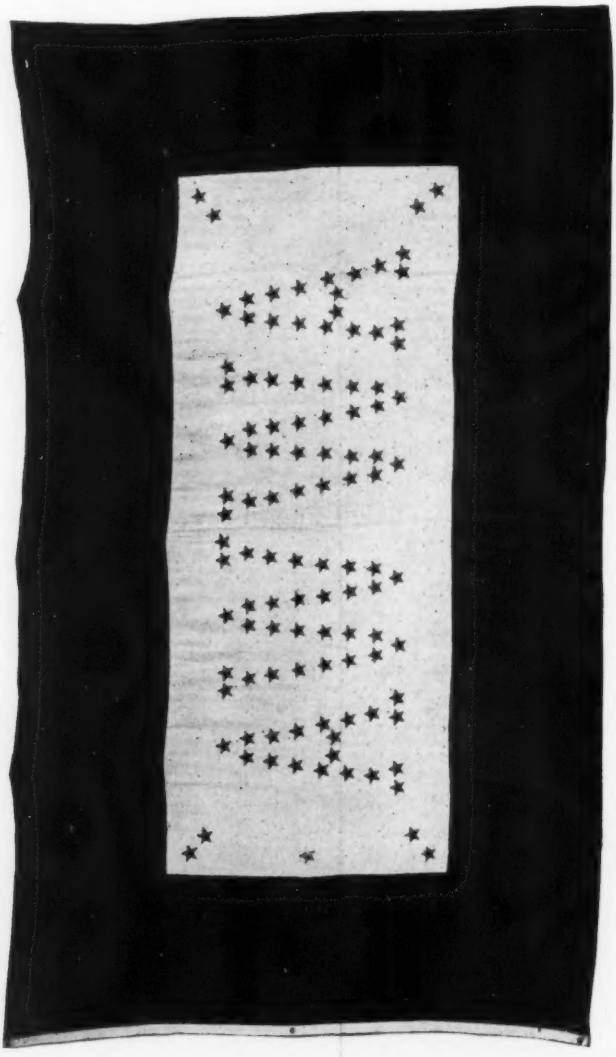
The Canvassing Committee, Jas. H. Caldwell and Wm. P. Mason, reported that the vote on the election of officers was unanimous for the regular nominees. The chair accordingly declared the following were duly elected officers for the ensuing year: President, Charles R. Henderson, Davenport, Iowa; Vice President, Carleton E. Davis, Philadelphia, Pa.; Treasurer, James M. Caird, Troy, N. Y. Trustees, term expiring 1921: Jack J. Hinman, Jr., Iowa City, Ia.; Allen W. Cuddeback, Paterson, N. J.

Geo. A. Johnson, Chairman, read the Report of the Executive Committee, which is printed on page 375.

On motion of Geo. A. Johnson, the Convention tendered to Miss Charlotte S. Edgley a unanimous and rising vote of thanks for presenting to the Association a service flag which was hung in the hotel lobby.

The recommendation of the Executive Committee advising remitting due of members in the military and naval service was discussed by

Messrs. Chester, Wiles, Kemble, Metcalf, Hatton, Cole and Diven. The Association voted to concur in the recommendation. On motion



SERVICE FLAG OF THE AMERICAN WATER WORKS ASSOCIATION
Made and presented to the Association at the convention in St. Louis, May, 1918, by Miss Charlotte S. Edgley, Assistant to the Secretary.

of Henry B. Morgan, it was voted that if any members have been dropped from membership while in the service because of non-payment of dues, such dues should be remitted and these members re-instated.

Geo. W. Fuller delivered an address, illustrated by lantern slides, explanatory of the emergency construction at the various cantonments from the water works standpoint. The address was discussed by Messrs. Metcalf, Little, Werner and Fuller.

On motion of F. C. Jordan, the following resolution was adopted by a unanimous rising vote:

RESOLVED: That Vice President Cuddeback be requested to telegraph to Ex-President Dabney H. Maury our deep sense of his valuable work in furtherance of the prosecution of the war, and our congratulations upon the success of his patriotic and fruitful efforts, and the pledge of the American Water Works Association to coöperate with Lieutenant-Colonel Maury in every way possible to still further develop and carry forward his plans.

The Report of the Special Advisory Committee on Amendments to the Constitution was presented; it is printed on page 355.

After discussion by Messrs. Metcalf, Chester, Wall and Henderson, the entire report of the Committee was concurred in and the several amendments as reported by them and distributed in printed form to the membership, were adopted as read.

Tuesday Night, May 14, 1918. Geo. A. Johnson in pursuance of a vote of the Executive Committee presented the following draft of a letter to Secretary McAdoo for consideration:

St. Louis, Mo., May 14, 1918.

Hon. William G. McAdoo,
Secretary of the Treasury,
Washington, D. C.

DEAR SIR:

The American Water Works Association, in convention assembled, contemplating with alarm the conditions existing with reference to difficulties experienced by its members during the past year in obtaining the materials essential to efficient and economical maintenance of satisfactory water service, is impelled to direct your attention to this extremely important matter and earnestly to express the hope that amelioration steps will be taken immediately that this highly essential branch of public service may not be allowed further to depreciate at the expense of increased public sickness, public discomfort, industrial inconvenience, faltering war activities and fire hazard.

The American Water Works Association is a national organization with about 1300 members, representing every state, 481 towns and cities, 37,000,000 persons in the United States, and water works in 18 foreign countries. It reports through its members—water works superintendents, commissioners, managers, engineers and operators,—increasing difficulties in construction, operation, and maintenance of their water works, and many examples fore-

boding menace to the public health and industrial war activities and of loss by fire due to impaired service.

Our water works superintendents and managers complain of great difficulty in obtaining reasonably prompt deliveries of materials essential to the satisfactory operation and maintenance of the works in their charge; manufacturers and builders of water works of futile results of applications to the Car Service Commission in efforts to obtain the delivery of materials without which the highly needed extensions or repairs to existing water works systems cannot be made. The situation is critical and merits immediate adjustment that the prosecution of the war be not hampered, nor the health and well being of the Nation be threatened, due to faltering or unsatisfactory water service.

To this end we respectfully commend to your favorable action the appended list of materials essential to the satisfactory and economical performance of the water departments of America, and request that they be placed at once on the essential list, and furthermore that they actually be given all reasonable priority in transportation.

Very respectfully,

THE AMERICAN WATER WORKS ASSOCIATION.

By ————, *President.*

Approved by the Executive Committee

Ratified by the Association in General Convention at St. Louis, Mo., May 14, 1918.

By————, *Secretary.*

On motion of Walter Edward Miller, seconded by Geo. W. Fuller, the recommendation of the Executive Committee was concurred in and the foregoing draft of letter approved, by unanimous vote.

A discussion on the increased cost of operation of water works and the difficulties under which they are being managed under war conditions, was held, in which Geo. A. Johnson, J. G. Chester, N. T. Veatch, Jr., and Leonard Metcalf participated.

E. R. Conant read a paper on "The Artesian Water Supply of Savannah, Ga.," which was discussed by J. N. Chester and Walter E. Miller.

In the absence of Louis L. Tribus, New York City, his paper on "Water Treatment Conditions at Council Grove, Kans." was read by Geo. A. Johnson, and discussed by C. C. Young.

Wednesday Morning, May 15. The President, Major Theodore A. Leisen, Q.M.R.C., officer in charge of utilities, Camp Custer, Mich., occupied the chair at this session and delivered the Annual Presidential Address, printed on page 250.

The chairman of the Finance Committee, George A. Johnson, presented its report, which is printed on page 376. In addition he gave in

detail the expenditures for the preceding year, so as to furnish the members with a full understanding of the proposed budget for the ensuing year. He further referred to the fact that there was a movement on foot to improve the character of the JOURNAL and allowance had been made for that, to be acted on by the incoming Executive Committee. On motion of J. N. Chester, the report was accepted and filed.

Chairman of Publication Committee presented the report of that Committee which is printed on page 380.

On motion of R. F. Johnson, the report was approved, especially its recommendations in regard to the JOURNAL.

The report of the Committee on Revision of Standard Specifications for Cast Iron Pipe and Specials, John H. Gregory, Chairman, was presented. It was the same report that was submitted at the Richmond Convention in May, 1917, and printed in the JOURNAL for September of that year, but was accompanied by a tentative draft of standard specifications printed on page 385 of this number. The report and specifications were sent to the members with a questionnaire. In reply to these questions, 33 voted in favor of revising the present specifications and 13 against revision or questioned its usefulness, 32 voted for and 12 against a uniform outside diameter, 26 voted for and 11 against specifying chemical requirements, and 29 voted for and 6 against specifying a relation between flexure and the breaking load. The report was discussed by E. E. Wall. H. B. Morgan, Leonard Metcalf, Walter Wood and T. A. Leisen, and at the close of the discussion it was voted to continue the Committee.

The following were selected members of the Nominating Committee from the several districts, viz.:

District 1. H. Hymmen, Kitchener, Ont.

District 2. Harry F. Huy, Buffalo, N. Y.

District 3. Chas. R. Wood, Philadelphia, Pa., and E. W. Humphrey, Erie, Pa.

District 4. Henry B. Morgan, Peoria, Ill., and W. W. DeBerard, Chicago, Ill.

District 5. J. A. Steele, Jr., Vicksburg, Miss.

District 6. John A. Caulfield, Bismarck, N. D.

In the voting for the next convention city, 114 votes were cast for Buffalo, and 52 votes for Detroit, and on motion of Mr. Wall, seconded by Major Leisen, the selection of Buffalo was made unanimous.

Albert P. Greensfelder, President American Society of Engineering Contractors, St. Louis, Mo., presented a paper on "De-Hydrated Contracts." On motion of Mr. Wall, the President was directed to appoint a special committee to draft a standard form of contract and bond, to report at the next convention.

Wednesday night, May 15. Jack J. Hinman, Jr., presented a paper on "Literature of Field Water Supply."

Robert B. Morse, and Abel Wolman presented jointly a paper on "The Practicability of Adopting Standards of Quality for Water Supplies," which was discussed by Jack J. Hinman, Jr., C. Arthur Brown, and W. S. Cramer.

On account of the lateness of the hour a paper on "Preliminary Analysis of the Degree and Nature of Bacterial Removal in Filter Plants," by Abel Wolman, was read by title.

Superintendent's day, Thursday morning, May 16. Vice President Cuddeback read the following telegram from Lieutenant-Colonel Maury:

> I am deeply grateful for message of congratulation and pledge of coöperation. The credit for whatever has been accomplished belongs to the entire Construction Division with which I was lucky enough to be associated. Please convey to my friends and fellow-members my most cordial greetings and best wishes for success of convention. Nothing but the work here could prevent my being with you.
>
> DABNEY H. MAURY.

Discussion on experiences with frozen services, mains and meters during the severe winter of 1917–1918 was opened by Vice-President Cuddeback and papers on the same subject were presented from F. E. Kingsbury, A. R. Hathaway, John T. Metcalf, J. M. Diven, Samuel E. Killam, J. Walter Ackerman, William W. Brush, and Charles A. Windholz. In addition there was oral discussion by W. H. Randall, C. W. Wiles, Robert C. Wheeler, Dr. M. P. Conway, Walter Edward Miller, Dow R. Gwinn, H. Hymmen, C. W. Schiedel. James P. Flatlay, F. T. Kemble, L. B. Landmann, Alvin Bugbee, Beekman C. Little, Wm. Luscombe, E. E. Davis, W. H. Randall, W. A. Judd, R. F. Johnson, A. F. Mellen, Wm. H. Henby, J. Arthur Jensen, and Henry P. Bohmann.

Superintendents' day, Thursday afternoon, May 16. Vice-President Cuddeback read a letter from Wm. W. Brush, calling special attention to a questionnaire on frozen services and mains, sent to members of the New York Section, which Mr. Bettes requested to have

laid before the Convention. Mr. Brush stated that the New York Section would not feel hurt if the convention should decide to have a committee appointed representative of all sections to secure the desired information.

Mr. Cuddeback referred to the extensive interest in frozen services and thought the subject could best be handled by a special committee to consider all of the papers presented and the discussions of the morning. On motion of W. H. Randall, the appointment of such a committee was authorized. The question as to whether it is advisable for the Association to adopt a standard form of electrical thawing machine was referred to the special committee just appointed.

Thomas E. Flaherty presented a paper on "Office Records," which was illustrated by lantern slides.

Mr. Cuddeback showed lantern slides illustrating office records and the method of keeping them.

F. M. Griswold addressed the convention, in reference to the national standard thread on all hose couplings and hydrant outlets.

Mr. Cuddeback presented a paper on "Water Consumption," illustrating it with lantern slides.

Office records and consumption were discussed by E. R. Townsend, Chester R. McFarland, and E. E. Davis.

Thursday night, May 16. A. V. Graf read a paper on "Some Aspects of Chemical Treatment at St. Louis Water Works," which was discussed by Dow R. Gwinn.

C. M. Daily read a paper on "The Double Forty-Eight Inch Manifold at Bissell's Point," illustrated by lantern slides. (No discussion.)

L. A. Day read a paper on "The New 110,000,000 Gallon Pump at Chain of Rocks," illustrated by slides. (No discussion.)

Friday morning, May 17. By unanimous vote, and with applause, the following telegram was read and ordered published in the JOURNAL.

France, May 17, 1918.

President American Water Works Association, St. Louis, Mo.

Greetings; Babbitt, Bartow, Bowles, Brennan, Buswell, Catlett, Ferguson, Fritze, Hale, Hadsen, Hawley, Hazlehurst, Lee, Letton, Mitchell, Murphy, Pugh, Roberts, Suter, Scharff, Walker, American Force.

[SIGNED] LONGLEY.

There being no one present representing the Committee on Standard Specifications for Wrought Iron Pipe, the committee was discharged and the President authorized to re-appoint if found advisable all of the members of the present Committee.

Philip Burgess, chairman of Committee on Mechanical Analysis of Sand, sent a letter stating that a progress report had been prepared, which was accompanied by notes by other members of the Committee; and on motion of Dow R. Gwinn this was referred to the Publication Committee. It is printed on page 345.

The Committee on City Planning, presented no report, the Chairman having resigned his membership in this Association. On motion of Mr. Gwinn, the committee was discharged, with thanks.

A letter was read from Nicholas S. Hill, Jr., chairman of the Committee on Private Fire Protection Service, advising that it had proved impossible to do anything during the present year by reason of several members of this committee being actively engaged on government work and unable to look after Association affairs. On motion, the Committee was discharged, and the president authorized to appoint a new Committee to undertake some positive action. A general discussion followed on the subject of private fire protection service, participated in by W. J. Wills, J. M. Diven, W. H. Randall, Dow R. Gwinn, Chester R. McFarland, E. E. Davis, Henry B. Morgan, George C. Habermeyer, E. E. Wall, J. Walter Ackerman, C. W. Schiedel, and A. W. Cuddeback. On motion of Mr. Gwinn, seconded by C. R. McFarland, the following resolution was adopted unanimously:

Resolved: That it is the sense of the American Water Works Association in Thirty-eighth Annual Convention assembled at St. Louis, Mo., May 14–17, 1918, that private fire protection is valuable and should be paid for by those who enjoy this unusual privilege; that the Water Works Department or Company shall in all cases specify the size of the connections to be made with the water mains; that no permit be issued for private fire protection connections without the approval of the Chief of the Fire Department; that all private fire protection lines shall be metered; that all those desiring private fire connections shall submit plans and blue-prints of the proposed lines through their factories or premises, and that no permit shall be issued for connection to the mains until such plans and blue-prints are filed with and duly approved by the Superintendent of the Water Department or Company; that in furnishing private fire protection the Water Department or Company does not guarantee to furnish the proper quantity of water through the fire protection services or to guarantee anything relative to such service; further that there shall be no connection between the fire protection services and any other source of supply.

No report having been received from the Committee on Official Standards of Water Analysis, the question of whether the Committee should be continued was left to the discretion of the President.

The Committee on Classification of Technical Literature was discharged, with thanks for the work it had done.

On motion of C. W. Wiles, the President was authorized to appoint a new Committee on Depreciation, the correspondence now in hand referring to this subject to be turned over to it.

On motion of Water Commissioner Wall, St. Louis, Mo., a unanimous vote of thanks was tendered to the United Railways Company of St. Louis for courtesies received.

On motion of Secretary Diven a rising vote of thanks was tendered to the Local Committees and especially the Ladies' Committees, for the way in which the visiting members and guests were entertained at St. Louis.

W. A. Foley read a paper on "Some Phases of Distribution Work," illustrated by lantern slides. The paper was highly commended by Chairman Cramer, and on motion of W. H. Randall a special vote of thanks was tendered the author.

ILLINOIS SECTION

The tenth annual meeting of the Illinois Section was held at Urbana on April 16 and 17. In welcoming the Section, Vice President David Kinley of the University of Illinois made the significant statement that there were not the same numbers of students to be seen because about 1800 undergraduates had gone into war service. It might be added that of seventeen members residing in Champaign and Urbana five are now army officers and three are working directly for the government. The attendance was 43, small for an annual meeting of this Section and due, according to Chairman E. MacDonald, to the absence in government work or arduous war-time labors of many of the men hitherto prominent in the Section's affairs. The treasurer reported that the Section was without indebtedness.

The papers presented were as follows:

"Unusual Winter Conditions at Evanston," I. C. Brower.

"Homemade Thawing Machine," F. C. Amsbary.

"Water Waste Elimination; Methods and Results at Oak Park," H. P. T. Matte.

"Letters from the Front," W. W. DeBerard.

"Storage of Coal," Prof. H. H. Stock.

"Reclamation," Prof. F. H. Newell.

"Water Supply and Sanitation at Government Camps," S. A. Greeley.

"Some Tests of Electrically Operated Deep-Well Pumps," P. S. Biegler and I. W. Fisk.

"Some Recent Sewage Treatment Work," W. D. Hatfield.

"The Property of Certain Water, with Reference to their Action on Metals," Prof. S. W. Parr.

"Reinforced Concrete Pressure Pipe," Coleman Meriwether.

"Pollution and Fish Life," Prof. Victor Shelford.

The Secretary, G. C. Habermeyer, reported that the Section had 110 active members, 1 corporate member and 14 associate members on April 16, 1918.

In the election of officers W. W. DeBerard was chosen chairman, W. E. Lautz vice-chairman, H. E. Keeler treasurer, and F. C. Amsbary trustee. H. M. Ely was elected trustee to fill the unexpired term of Mr. Lautz.

During the meeting the annual dinner was served at Hotel Beardsley, the University student brigade was reviewed, and a visit paid to Chanute Field aviation school.

The following resolution was adopted:

WHEREAS, Circular No. C. S. 1-A, issued March 26, 1918, by the United States Railroad Administration states that liquid chlorine, alum, sulphate of iron and similar chemicals are exempt from embargo when to be used for purification of public water supplies and consigned to municipal authorities, and

WHEREAS, it is apprehended that some local railroad officials may interpret the wording "municipal authorities" too strictly in case of private ownership of plants, and

WHEREAS, other materials in addition to chemicals are just as essential to the proper protection of the health and property of the community, Therefore be it

Resolved, that the Illinois Section of the American Water Works Association recommend to the American Water Works Association that it take up the matter of relief in shipments of materials for the maintenance and operation of public water supplies by requesting United States Railroad Administration, Division of Transportation, Car Service Section, for priority of such materials and supplies.

OBITUARY NOTICES

B. F. Souder, Superintendent of Distribution, Atlantic City, N. J.; elected June 24, 1913; died May 23, 1918.

William R. Hill, Consulting Engineer, Albany, N. Y.; elected member, June 9, 1897; died June 16, 1918.

TREASURER'S REPORT

Troy, N. Y., March 31, 1918.

Permit me to submit my report as Treasurer of The American Water Works Association for the year ending March 31, 1918.

The funds of the Association are on deposit with The Troy Trust Company, Troy, N. Y.

The receipts during the year were as follows:

Balance April 1, 1917	$3,262.36
Received from J. M. Diven, Secretary	10,568.01
Interest on deposits	118.92
Interest on investments	335.00
Total	$14,284.29
Disbursements as per vouchers, cancelled checks and debit slips	$12,796.59
Balance, April 1, 1918	$1,487.70

The disbursements include $5,000.00 used for the purchase of United States Liberty Bonds for the Permanent Fund.

Attached you will find certificate of The Troy Trust Company showing a deposit of $1,511.80 at the close of business March 30, 1918.

From this balance there should be deducted the following for unreturned checks.

Deposit as per certificate		$1,511.80
Unreturned checks		
V785—Ck. 955 A. C. Schmidt	11.50	
793—Ck. 963 Nora Pederson	3.00	
794—Ck. 964 H. A. Whittaker	5.85	
795—Ck. 965 Williams & Wilkins Co.	3.75	$24.10
Balance, April 1, 1918		$1,487.70

The receipted vouchers, cancelled checks and debit slips with the book of the Treasurer are submitted for audit.

The Permanent Fund now consists of the following:

4-$1,000. Dominion of Canada 15 yr. 5% Bonds. (no. 23795-24460-24693-24694)	$4,000.00
2-$1,000. Am. Foreign Sec. Co. 3 yr. 5% Notes. (M-31719-M31720)	$2,000.00
4-$500. U. S. Liberty Loan of 1917 3-½% Bonds. (113880-113881-113882-113883)	$2,000.00

1-$1,000.	U. S. Liberty Loan of 1917 4% Bond. (114824)...	$1,000.00
1-$2,000.	U. S. Certificate of Indebtedness 4-½%.....	$2,000.00
Par value of permanent fund.....		$11,000.00

The Treasurer receives no salary and is under bond as per the order of your Committee.

JAMES M. CAIRD,
Treasurer.

THE TROY TRUST COMPANY

Troy, N. Y., March 30, 1918.

This is to certify that at the close of business March 30th, 1918, the balance to the credit of the American Water Works Association was Fifteen Hundred Eleven and 80/100 Dollars ($1,511.80).

HAROLD K. DOWNING,
Vice-President.

REPORTS OF COMMITTEES

REPORT OF EXECUTIVE COMMITTEE

The present Executive Committee met for organization following the announcement of the election of officers at the convention at Richmond last May, and elected John M. Diven, secretary, John M. Goodell, editor, and George A. Johnson, chairman of the Finance Committee.

A meeting of the Executive Committee was held at the Hotel Astor, New York City, on December 1, 1917, at which the chairman of the Constitutional Revision Committee reported. All members of the Executive Committee, with the exception of Mr. Rust, were present. The proposed revision of the Constitution was thoroughly discussed, and a final revision was agreed upon for submission to this convention.

At the request of the American Society of Mechanical Engineers, Nicholas S. Hill, Jr., with John N. Chester as alternate, was appointed as a representative to attend the public hearing on the Power Test Codes of that Society held in New York City, December 7, 1917.

The honor roll was brought up for discussion, and it was decided to include in this roll not only the members but also the sons and daughters in service, and to print the honor roll in the JOURNAL, and to display in a conspicuous place at the convention a service flag. Mr. Diven announced that Miss Edgley, his assistant, desired to furnish a service flag for the Association. The Executive Committee accepted the offer with gratitude, and now suggests that a vote of thanks by the convention for this very much appreciated service to the Association would be appropriate.

The following resolution was adopted:

RESOLVED: That the Executive Committee recommends to the Association that the dues of all members entering the service of the Army or Navy of the United States, or its Allies, be remitted during the period of the war.

Mr. Kienle appeared before the Executive Committee to ask for a definition of its policy with regard to the giving of badges to

associate members who are not members of the Manufacturers' Association, and to guests. The Executive Committee informed him that it could not discriminate between associate members who were and who were not members of the Manufacturers' Association, and that the associate members' badge must be given to all associate members on application, regardless of the Manufacturers' Association; that the Manufacturers' Association might if it so wished add to the regular badge of associate members some distinctive mark which would indicate that an associate member was also a member of the Manufacturers' Association; that while the Executive Committee believed it advantageous generally for associate members to become members also of the Manufacturers' Association, it could take no action directed to forcing associate members to become also members of the Manufacturers' Association; that in view of the growth in importance of the convention to the technical press, as indicated by the increased number of its representatives present at the convention, it was of the opinion that it would be desirable for the various publications having representatives in the Association to become associate members; but that the standing of the representatives of the press who were already or who might become active members of the Association would be in no wise affected by this action, and that it was clearly the sense of the Executive Committee that the guest privilege should not be asked for the additional representatives of associate members wishing to attend the convention with commercial ends in view.

ALLAN W. CUDDEBACK,
Chairman.

REPORT OF THE FINANCE COMMITTEE FOR THE YEAR ENDING MARCH 31, 1918

The Finance Committee present the following report on the financial operations of the Association for the year ending March 31, 1918:

We have audited the books of the secretary and treasurer and found them correct. We have examined and verified all vouchers. Details of the financial operations of the Association, and the various funds and accounts, are fully set forth in the respective reports of the secretary and treasurer, and are in accord with their books. Following is a summarized statement of the past year's accounts:

Summarized statement of accounts for the fiscal year ending March 31, 1918

Balance on hand in bank on April 1, 1917	$3,262.36	
Received from the Secretary	10,568.01	
Interest on deposits	118.92	
Interest on investments	335.00	
Total		$14,284.29
There has been disbursed and paid by the Treasurer on vouchers duly authorized and audited by the Finance Committee for the general operations of the Association	$7,796.59	
There was added to the permanent Investment fund	$5,000.00	
Total		$12,796.59
Leaving on April 1, 1918 a balance in bank to the credit to the Association of		$1,487.70

PERMANENT INVESTMENT FUND

There are now in the hands of the Treasurer, in accordance with the authority granted the Finance Committee by the Executive Committee, securities constituting the Permanent Investment Fund of the Association, as follows:

Four $1000 Dominion of Canada 5% bonds, due April 1, 1931	$4,000.00
Two $1000 American Foreign Security Company 5% notes due August 1, 1919	2,000.00
Four $500 United States First Liberty Loan Bonds, 3½%.	2,000.00
One $1000 United States Second Liberty Loan Bond, 4%.	1,000.00
One $2000 United States Certificate of Indebtedness, 4½%	2,000.00
Par value of Permanent Investment Fund	$11,000.00

On April 1, 1917, there was a balance of $3,262.36 cash in bank. As against this the former Finance Committee had subscribed to the first issue of Liberty Loan Bonds in the amount of $2,000. These were taken up and paid for during the past fiscal year as noted above, and other additions, totalling $3000, were made to the permanent investment fund. At the beginning of the past fiscal year the par value of the permanent investment fund was $6,000. At present it is $11,000.

BUDGET ALLOWANCES AND DISBURSEMENTS

The budget allowance voted by the Executive Committee for the past fiscal year amounted to a total of $11,175.

That the expenditures against no item in the budget for 1917–18 exceeded the allowance is a cause for some gratification. In detail it may be recorded that the convention expenses at Richmond were moderately low. Office expenses for the year were kept well within the allowance. Election expenses were approximately equal to the allowance.

Disbursements for committee expenses amounted to but 32 per cent of the allowance. The expenses of the Executive Committee, amounting to a total of $380.44, and occasioned by a meeting held in New York on December 1, 1917, were borne by the committee, each member paying his pro rata share.

Disbursements for section expenses were well within the allowance. The salaries of the secretary and editor are fixed by the Executive Committee, and the disbursements and allowances consequently balance.

The allowance for printing the JOURNAL was made somewhat more liberal last year in anticipation of increased postal rates and printing charges. These increases did not materialize, and the expenditures against this item amounted to but 60 per cent of the allowance. Expenditures under the contingencies item were restricted to efforts to increase the membership.

Respecting the budget for the fiscal year 1918–1919, the recommended allowances are made on the assumption that the proposed constitutional amendments will be ratified at the St. Louis meeting.

Recommended budget for the year 1918–1919

Convention expenses	$700.00
Office expenses	700.00
Election expenses	200.00
Committee expenses	1,000.00
Section expenses	600.00
Insurance	75.00
Salary of Secretary	1,500.00
Salary of Editor	800.00
Extraordinary expenses of the secretary, treasurer and editor	425.00
Printing and distributing JOURNAL	5,500.00
Total	$11,500.00

Respecting the suggested budget we have the following comments to make:

The allowance for election expenses has been made somewhat larger than last year in order to meet the added expense anticipated by the new procedure in electing officers, necessitating considerable additional printing and postage.

On the assumption that the constitutional amendments are ratified at the St. Louis meeting, members of the Nominating and Convention Committees are to be reimbursed for travelling expenses. In the suggested budget we have estimated such expenses of the Nominating Committee meeting at $280, and those of the Convention Committee at $120. The balance of the allowance for Committee expenses, amounting to $600, should be sufficient to defray the cost incurred for stenographic services, printing and postage by all other committees, including the Additional Membership Committee and Committee on Superintendents Convention Expenses, if such committees are appointed. We believe an allowance of $250 ample for the expenses of the former, and $100 for those of the latter.

In lieu of increasing the salaries of the secretary and editor, it has seemed to us wiser to provide a new item in the budget to take care of extraordinary expenses of these officers who at present pay their own expenses when attending the annual conventions and other committee meetings where their presence is requested. The salaries paid the secretary and editor are not much more than enough to defray the cost of such assistance as they require in the performance of their duties, and it would seem only fair that the Association should make suitable provision for their expenses incurred in attending annual and called meetings, and at times when they are obliged to engage the services of additional stenographic assistance, that they may not be required actually to contribute more than their own time while serving the Association. Accordingly we have introduced an item in the budget under the head of Extraordinary Expenses of the Secretary, Treasurer and Editor to cover these expenses, and hope that our action will be approved.

In the work of our committee during the past year we have carried all accounts on budget depletion sheets, and have found it very helpful to thus have constantly before us a convenient and accurate statement of drafts against and credit balance in each item.

The operations for the past three years have shown an average surplus of nearly $3,000. A well organized plan of campaign for new members would, we believe, result in positive assurance that this annual surplus will be not only maintained but increased materially.

A better journal, that is, one containing a selection of high grade papers covering a wide variety of subjects, such as can well be obtained through judicious soliciting by the Publication Committee, will increase the revenue from subscriptions and advertisements. These are important items, and it must not be forgotten that a high grade journal will not only hold existing members but serve a material purpose in any campaign for getting new members.

The treasurer is now under bond for $10,000, as per order of the Executive Committee.

In conclusion we desire to express our appreciation of the hearty coöperation we have received from the secretary and treasurer, and other officials of the Association, and to state our gratification over the harmonious manner in which it has thus been made possible for us to perform our duties.

GEORGE A. JOHNSON, *Chairman.*
J. WALDO SMITH,
FRANK A. BARBOUR.
Finance Committee.

REPORT OF THE PUBLICATION COMMITTEE FOR THE YEAR ENDING MARCH 31, 1918

The Publication Committee was not organized until late in the year, but since then has been giving much thought to the JOURNAL. As a result of its deliberations, the Committee recommends to its successor a more active endeavor to increase the value of the JOURNAL to our members and to all interested in water supply. This quarterly publication is the sole direct return many of our members receive from their dues, and the Publication Committee should make every practicable effort to have this return as large and useful as the funds at its disposal permit. The present Committee believes that material improvements can be made with very little additional expense, provided the members of the Association will coöperate. This is particularly important because, by a modification of some of our existing methods of conducting our meetings, the usefulness of our papers to our members can be materially increased, sectional meetings can be broadened, and our printed records made more representative of the thought of our entire Association.

The present Committee feels very strongly the importance of this subject, because it is so closely related to the purpose of the

Association to be American in fact as well as in name. In these grim days of lofty purpose and most earnest endeavor, when America is giving her all in a cause for which the only possible result of complete success is freedom for all nations, great and small, from the domination of a military autocracy, we must leave untried no means of improving the service we can render the communities we serve. Without the adequate supply of wholesome water which it is our business, our duty, to furnish, all our industry would falter and the prosecution of the war would suffer. We are soldiers who serve at home, and we must serve the best we can in this way.

The best service is only practicable when those striving to render it have at their disposal the experience and opinions of all similarly engaged. The JOURNAL of the American Water Works Association ought to furnish that information. It is not doing so now to the extent it should, and your Committee believes the material improvement of the JOURNAL is one of the duties of the incoming officers which should receive careful attention.

It is quite commonly said that water works construction and management have become so standardized that nothing new, nothing really helpful in a broad sense, is practicable. Your Committee dissents strongly from such a view. Whether a water department is bubbling with vitality or stagnant with mere routine depends largely on the enthusiasm of those at its head. Standardization is a valuable feature of administrative organization, but standardization for all time, never changing routine, is a sure indication of senility. "Only the minds of fools stand still." What we have to do as an Association is to keep our individual members animated with the knowledge of all the progress in our field, and those who say there is no progress worth mentioning in our field, asperse the thousands of men earnestly striving to serve our communities more efficiently, more economically and more intensively.

Unfortunately a considerable part of the progress of our industry is essentially and necessarily slow. Somebody takes a step forward here, another there, a third yonder, and so on until the knowledge of these little advances becomes generally distributed, and we wake up to the fact that the advance has been substantial. For instance, take the progress in sanitary drinking fountains. A few years ago attention was called to the probability that some of these fountains were sanitary only in name. Tests of them were made in

a few places, but it was not until a committee of our Iowa section started an investigation of the subject that sanitarians and water works superintendents realized to any extent that there are "sanitary" drinking fountains which are a distinct menace to health, comparable as such with the public drinking cup. The report of the special committee on sanitary drinking fountains of the Iowa Section will be printed next month in the JOURNAL, and may be taken as a good example of the kind of work which shows that water works administration is not to be classed with driving the cows to pasture but calls for wide knowledge, good judgment and "pep."

The present Publication Committee is convinced that much more work like that of the committee just mentioned should be done. It therefore requests this convention to authorize the President to appoint from time to time such special committees to report on features of water works practice as the president and Publication Committee deem desirable, these committees to report to the Publication Committee. If the reports are considered by the Publication Committee to be in form for discussing, copies should be sent to the secretary of each section, if received early in the Association's year, so that they may be discussed by each section. If received late in the year they can be presented at the annual convention.

This recommendation is made for two reasons. First, it will enable the Publication Committee to start committee work promptly when it is desirable to place the results of that work before the members as quickly as possible. Second, it will enable the Publication Committee to be of greater service to the Sections by aiding them in securing reports on timely topics for their meetings. It will tend to increase the interest in the Sections, to animate the Association and thus increase its membership. The success of the work will depend on the members of these special committees, but it is believed they will not fail, for the topics will be live issues and not pedantic platitudes, such as have killed so many of our committees in the past.

The present Publication Committee also strongly advises its immediate successor to secure papers from individuals known to have made investigations or had experiences of interest to water works officials. The essential purpose of this Association is to help the American people secure wholesome water at the lowest

cost. This calls for engineering, chemical and bacterial knowledge, skill in construction and administrative ability. There are various associations and publications supplying a record of progress in some parts of this list, but there is no organization and no publication, even our own, that has the firm grip on the water works field of activity which is desirable from the viewpoint of good municipal administration. Our JOURNAL must be strengthened by becoming a record of live things, a record of what we are striving for as well as what we have done, before it will itself become really alive. And the only way for it to become alive is to secure the coöperation of those men whose work is resulting in progress. By this we do not mean merely progress in great problems, but progress in the minor but often very perplexing smaller tasks of the water works official.

By requesting papers from individuals able to make useful contributions to the JOURNAL, and by securing the assistance of committees where it is necessary to make comprehensive investigations of a subject, it will be practicable to serve the members better than by following the old publication policy of printing only papers originating in the annual convention or the meetings of the sections. The last Publication Committee considered these methods of improving the JOURNAL, but hesitated about adopting them on account of the possibility of overstraining the financial budget of the Committee through an excessive amount of material for publication. It was justified in this fear by the needlessly long and detailed character of part of the material submitted for publication. The present Publication Committee does not have the same fear, because it believes that the time has come for materially condensing some of the papers it receives. It is not the quantity but the quality of the information in the JOURNAL that will make it most interesting and most useful. Papers that are interesting locally may have only parts of general interest, and the Publication Committee believes that those parts of local interest can be omitted without material loss. This pruning may cause some members to feel injured, to think that it is not worth while writing papers if they are to be cut up and boiled down. Yet this must be done, not only to make the JOURNAL more widely interesting but also to save the time of members who wish to read everything about real progress in water works affairs but wish to be saved the task of picking the wheat of utility from the chaff of merely local interest.

If we can make the JOURNAL more useful, more authoritative, more comprehensive in scope, more alive, we can secure more members and, with greater membership, wield more influence for those improvements needed to give our people all the good water they need.

GEORGE A. JOHNSON, *Chairman.*
WM. W. BRUSH,
H. W. CUDDEBACK,
JAMES W. ARMSTRONG,
JOHN M. GOODELL, *Editor.*
Publication Committee.

TENTATIVE DRAFT OF PROPOSED STANDARD SPECIFICATIONS FOR CAST IRON PIPE AND FITTINGS[1]

DESCRIPTION OF PIPE

SECTION 1. The pipes shall be made with *bell* and spigot *ends or with flange ends* and shall *conform accurately* to the dimensions given in Tables Nos..... and ..... They shall be straight and shall be true circles in section, with their inner and outer surfaces concentric, and shall be of the specified dimensions in outside diameter.

Bell and spigot pipes shall be at least 12 feet in laying length, exclusive of the bell, and flange pipes shall be at least 12 feet in length face to face of flanges.

All classes of pipe of each size shall have the same outside diameter. All pipes having the same outside diameter shall have the same inside diameter at both ends.

The inside diameter of the lighter pipes of each standard outside diameter shall be gradually increased for a distance of about 6 inches from each end of the pipe barrel, so as to obtain the required standard thickness and weight for each size and class of pipe.

DESCRIPTION OF FITTINGS

SECTION 2. *There shall be two types of standard fittings, known as "Bell Fittings" and "Flange Fittings." Fittings having bell or spigot ends, or both, but no flange end or ends, shall be known as "Bell Fittings." Fittings having one or more flange ends shall be known as "Flange Fittings."*

All fittings shall be made in accordance with the cuts and dimensions given in the tables forming a part of these specifications. They shall be true circles in section with their inner and outer surfaces concentric

[1] Submitted to the St. Louis convention May 15, 1918.

Changes from present New England and American specifications are in italics.

on both run and outlet, except where intersections prevent. On all fittings the outside diameter of the barrel on each outlet shall be the same as the outside diameter of the pipe of corresponding size.

For pipes from 4 to 20 inches in diameter, inclusive, one class of fittings known as Class D fittings shall be furnished for all classes of pipe. For pipes over 20 inches in diameter, two classes of fittings, known respectively as Class AB and CD fittings, shall be furnished, Class AB fittings for Class A and Class B pipes, and Class CD fittings or Class C and Class D pipes.

Any fitting not shown in the tables hereto attached shall be known as a "Special Fitting."

VARIATION IN DIAMETER OF BELLS AND SPIGOTS

SECTION 3. Especial care shall be taken to have the *bells* and spigots of the required size. The *bells* and spigots will be tested by circular gages, and no pipe or *fitting* will be accepted *which, for any cause, does not comply with the specified joint space, except as hereinafter allowed.*

The inside diameters of the bells and the outside diameters of the spigot ends of pipes shall not vary from the standard dimensions by more than 0.06 inch for pipes 16 inches or less in diameter; 0.08 inch for pipes 18, 20 and 24 inches in diameter; 0.10 inch for pipes 30, 36 and 42 inches in diameter; 0.13 inch for pipes 48, 54 and 60 inches in diameter; *and 0.18 inch for pipes 72 and 84 inches in diameter.*

The inside diameters of the bells and the outside diameters of the spigot ends of the fittings shall not vary from the standard dimensions by more than 0.08 inch for fittings 16 inches or less in diameter; 0.10 inch for 18-, 20-, and 24-inch fittings; 0.13 inch for 30-, 36-, and 42-inch fittings; 0.16 inch for 48-, 54- and 60-inch fittings; and 0.20 inch for 72- and 84- inch fittings.

VARIATION IN THICKNESS

SECTION 4. For pipes whose standard thickness is less than 1 inch the thickness of metal in the body of the pipe *shall not vary more than 0.08 inch* from the standard thickness, and for pipes whose standard thickness is 1 inch or more, the variation shall not exceed 0.10 inch., except that for spaces *the length across which in*

any direction does not exceed 8 inches, a decreased thickness not exceeding 0.02 inch will be permitted, and for spaces the length across which does not exceed 16 inches in any direction, an increased thickness not exceeding 0.05 inch will be permitted—both in excess of the allowances above stated.

For fittings, a variation 50 per cent greater than that allowed for pipes shall be permitted.

ALLOWABLE PERCENTAGE OF VARIATION IN WEIGHT

SECTION 5. No pipe shall be accepted, the weight of which shall be less than the standard weight by more than 5 per cent for pipes 16 inches or less in diameter and 4 per cent, for pipes more than 16 inches in diameter, and no excess above the standard weight of more than the above given percentages for the several sizes shall be paid for. The total weight of pipe to be paid for shall not exceed, for each size and class of pipe received, the sum of the standard weights of the same number of pieces of the given sizes and classes by more than 2 per cent.

No *fitting* shall be accepted, the weight of which shall be less than the standard by more than 10 per cent for *fittings* 12 inches or less in diameter and 8 per cent for larger sizes (except that curves and Y-branches may be 12 per cent below the standard weight); no excess above the standard weight of more than the above given percentages for the several sizes shall be paid for. *The total weight of fittings to be paid for shall not exceed the sum of the standard weights of the same number of pieces of the given sizes and classes by more than 5 per cent.*

QUALITY OF IRON

SECTION 6. All pipes and fittings shall be made of cast iron of good quality and of such character as shall make the metal of the casting strong, tough, and of even grain, and soft enough satisfactorily to admit of drilling and cutting. The metal shall be made without *the admixture of any inferior material*, and shall be remelted in cupola or air furnace.

The contractor shall furnish the engineer with copies of the mill analyses of each heat or run of metal, and shall furnish samples to the engineer for check analyses when required.

The metal for the pipes and fittings shall fulfil the following chemical requirements: Total carbon, 3 to 3.75 per cent; combined carbon, 0.5 to 0.75; silicon, 1.6 to 2; manganese, 0.35 to 0.55; phosphorus, not to exceed 0.90; sulphur, not to exceed 0.10 per cent.

TESTS OF MATERIAL

SECTION 7. Specimen bars of the metal used, each being 26 inches long by 2 inches wide and one inch thick, shall be made, without charge, as often as the engineer may direct, and in default of definite instructions the contractor shall make and test at least one bar from each heat or run of metal. The bars, when placed flatwise upon supports 24 inches apart and loaded in the center, shall support a load of 2000 pounds, and show a deflection of not less than *0.32 inch before breaking, and an increase in deflection of not less than 0.03 inch for each 200 pounds of ultimate breaking load in excess of 2000 pounds.*

The contractor shall have the right to make and break three bars from each heat or run of metal, and the test shall be based upon the average results of the three bars. Should the dimensions of the bars differ from those above given, a proper allowance therefor shall be made in the results of the tests.

CASTING OF PIPE

SECTION 8. The pipes shall be cast in dry sand molds in a vertical position. Pipes 16 inches or less in diameter *may* be cast with the *bell* end up or down, unless *otherwise* specified *by the purchaser.* Pipes 18 inches or more in diameter shall be cast with the bell end down.

The pipes shall not be stripped or taken from the pit while showing color of heat, but shall be left in the flasks for a sufficient length of time to prevent contraction by subsequent exposure.

QUALITY OF CASTINGS

SECTION 9. The pipes and fittings shall be smooth, free from scales, lumps, blisters, sand holes and defects of every nature which, in the opinion of the engineer, unfit them for the use for which they are intended. No plugging or filling will be allowed.

MARKING

SECTION 10. *Each* pipe and *fitting* shall have distinctly cast upon it the initials of the maker's name, a *letter designating the class to which the casting belongs, and figures showing the year in which it was cast. When cast to order, if required by the purchaser, each pipe and fitting 6 inches or more in diameter shall also have cast upon it a serial number, designating the order in point of time in which it was cast, the serial number to be placed below the date, thus:*

1916	1916	1916
1	2	3

etc., and any initials, not exceeding four, *or a symbol,* which may be required.

The letters and figures shall be cast on the outside, and shall *be not* less than 2 inches in length and $\frac{1}{8}$ inch in relief for pipes *and fittings 10 inches* in diameter and larger. For smaller sizes of pipe, the letters may be 1 inch in length. The weight, *serial number,* and class letter shall be conspicuously painted in white on the inside of each pipe and *fitting* after the coating has become hard.

DEFECTIVE SPIGOT ENDS MAY BE CUT

SECTION 11. Defective spigot ends on pipes 12 inches or more in diameter may be cut off in a lathe, and half-round wrought-iron or *mild-steel* band, shrunk into a groove, cut at the end of the pipe. Not more than 12 per cent of the total number of accepted pipes of each size shall be cut and banded, and no pipe shall be banded which is less than 11 feet in length, exclusive of socket.

Pipes may be cast with shrink-head above spigot bead, and such pipe shall not be considered as cut pipe in determining the percentage above referred to.

In case the length of pipe differs from 12 feet, the standard weight of the pipe given in Table shall be modified in accordance therewith.

FLANGES

SECTION 12. *Flanges shall be cast solid and shall be accurately faced smooth and true. Holes for bolts or studs shall be drilled, and the flanges shall be tapered where required. The contractor shall furnish and deliver all bolts and nuts for bolting on manhole covers. The*

bolts and nuts shall be of the best-quality wrought iron or mild steel, with good, sound, well-fitting threads, the nuts to be cold punched. The heads and nuts shall be hexagonal and shall be trimmed and chamfered. The heads, nuts and threads shall be of the United States Standard sizes.

CLEANING AND INSPECTION

SECTION 13. All pipes and *fittings* shall be thoroughly cleaned and subjected to a careful hammer inspection. No casting shall be coated unless entirely clean and free from rust, and approved in these respects by the *engineer* immediately before being *coated.*

COATING

SECTION 14. Every pipe and *fitting* shall be coated inside and out with coal-tar pitch varnish. *Each pipe and fitting shall be heated to a uniform temperature of 320° F., in a suitable oven, before it is dipped, and the material in the tank shall also be maintained at this temperature, and each pipe and fitting shall be kept in the bath for at least five minutes, during which time the temperature of all parts of the bath, including the bottom, shall be as specified.*

After removing the pipe from the bath, it shall be suspended or set in a vertical position until the coating has solidified.

The coating shall be of pitch, made from coal tar, distilled until the naphtha is removed, and sufficient oil to make a smooth coating, tough, elastic, strongly adhesive to the metal, tough and tenacious when cold, and not brittle nor with any tendency to scale off. Coating shall not be soft enough to flow when exposed to summer heat, nor brittle enough to crack and scale when exposed to a temperature below freezing.

The pitch shall be straight-run, coal-tar pitch, which shall soften at 60°F. and melt at 100°F., being a grade in which distillate oils, distilled therefrom, shall have a specific gravity of 1.05. The pitch shall not contain less than 10 per cent nor more than 18 per cent of free carbon.

Fresh pitch and oil shall be added to the tank when necessary to keep the mixture of the proper consistency. The oil used for this purpose shall consist of heavy, coal-tar oil, with a specific gravity of not less than 1.04 at 60°F., and which shall not lose more than 5 per cent of oil when distilled up to 400°F.; not more than 40 per cent of oil when

distilled up to 450°F. If the material in the tank thickens or deteriorates when used, the tank shall be emptied of its contents and refilled with fresh material when deemed necessary by the engineer.

Fittings which are too large to be immersed shall be coated with hot varnish by hand, the fittings to be heated as specified above and the coating applied immediately thereafter.

Faces of flanges and finished surfaces shall be coated with a mixture of grease and white lead immediately after they have been faced and drilled.

Any pipe or *fitting* that is to be recoated shall first be thoroughly scraped and cleaned.

HYDROSTATIC TEST

SECTION 15. When the coating has become hard, the pipe shall be subjected to a proof by hydrostatic pressure, and if required by the engineer, they shall also be subjected to a hammer test under this pressure.

The pressures to which the different sizes and classes of pipe shall be subjected are as follows:

CLASS	HYDROSTATIC PRESSURE POUNDS PER SQUARE INCH	
	Diameter less than 20 inches	Diameter 20 inches and ver
A	300	150
B	300	200
C	300	250
D	300	300

The full hydrostatic pressure shall be applied to the pipes for one minute on pipes 12 inches and less diameter; for two minutes on 14-, 16-, 18-, 20- and 24-inch pipes; for three minutes on 36-inch pipes; and for five minutes on pipes larger than 36 inches in diameter.

Fittings shall also be subjected to a proof by hydrostatic pressure, provided the same is specified in the contract. If tested, the hydrostatic pressures to which the fittings shall be subjected shall be the same as those to which pipes of the same size and class would be subjected and shall be applied for the same length of time.

WEIGHING

SECTION 16. The pipes and *fittings* shall be weighed for payment under the supervision of the engineer after *they have been coated.* If desired by the purchaser, the pipes and *fittings* shall be weighed after their delivery. The weight so ascertained shall be used in the final settlement, provided such weighing is done by a legalized weigh master. *The cost of weighing after delivery shall be borne by the purchaser.*

Bids shall be submitted and final settlement made upon the basis of a ton of 2000 pounds.

CONTRACTOR TO FURNISH MEN AND MATERIAL

SECTION 17. The *contractor* shall provide all tools, testing machines, materials and men necessary for the required testing, inspection and weighing at the foundry of the pipes and *fittings*, and should the purchaser have no inspector at the *foundry*, the contractor shall, if required by the purchaser, furnish a sworn statement that all of the tests have been made as specified, this statement to contain the results of *the chemical and physical tests.*

POWER TO INSPECT

SECTION 18. The engineer shall be at liberty at all times to inspect the material at the foundry and the molding, casting and coating of the pipes and *fittings.* The forms, sizes, uniformity and conditions of all pipes and *fittings* herein referred to shall be subject to his inspection and approval, and he may reject, without proving, any pipe or *fitting* which is not in conformity with the specifications or drawings furnished.

INSPECTOR TO REPORT

SECTION 19. The inspector at the foundry shall report daily to the contractor all pipes and *fittings rejected*, with the causes for rejection.

CASTINGS TO BE DELIVERED SOUND AND PERFECT

SECTION 20. All pipes and *fittings shall* be delivered in all respects sound and conformable to these specifications. The inspection shall

not relieve the contractor of any of his obligations in this respect, and defective pipes or *fittings* which may have passed the engineer at the foundry or elsewhere shall be at all times liable to rejection, when discovered, until the final completion and adjustment of the contract, provided, however, that the contractor shall not be held liable for pipes or *fittings* found to be cracked after they have been accepted at the agreed point of delivery. Care shall be taken in handling the pipes *and fittings* not to injure the coating, and no pipes, *fittings* or other material of any kind shall be placed in the pipes or *fittings* during transportation *or at* any time after they have *been coated.*

The contractor shall not be held responsible for any expenses or damages incurred in handling or using the castings after they have been accepted at the agreed point of delivery. Any pipe or fitting that proves defective shall, when requested, be replaced by the contractor, the measure of the damage not to exceed the value of the casting found defective. The contractor shall have the right to call for the defective casting to be returned to him at the agreed point of delivery before any allowance for the same is demanded.

DEFINITION OF THE WORD "ENGINEER"

SECTION 21. Wherever the word "engineer" is used herein, it shall be understood to mean the engineer or inspector acting for the purchaser, and his properly authorized agents, limited by the particular duties intrusted to them.